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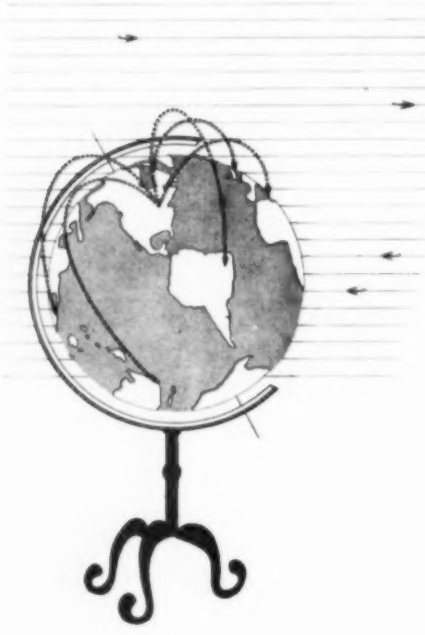

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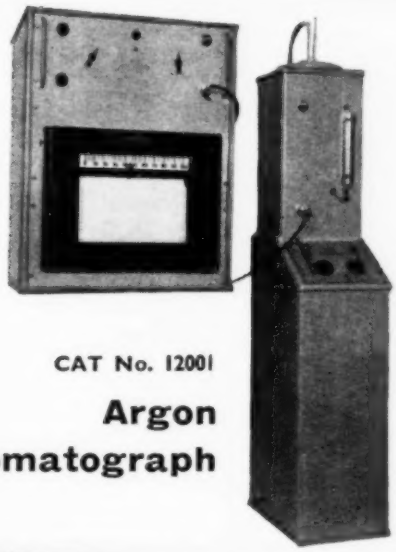

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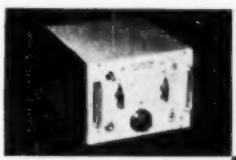

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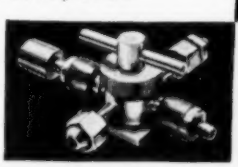

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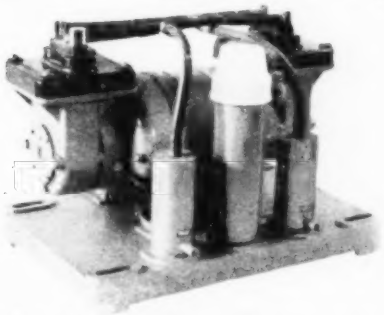

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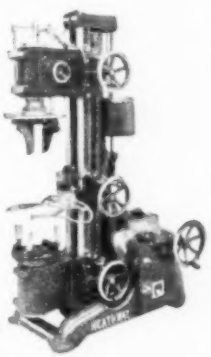

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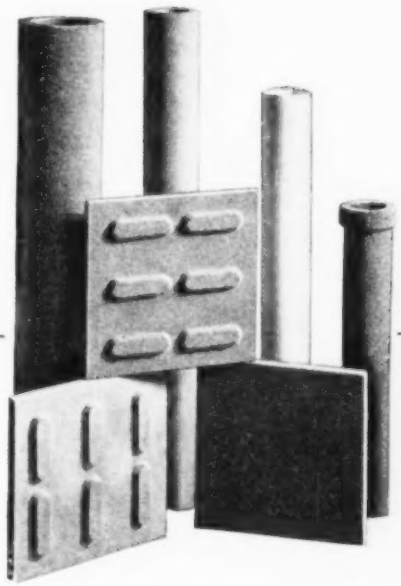

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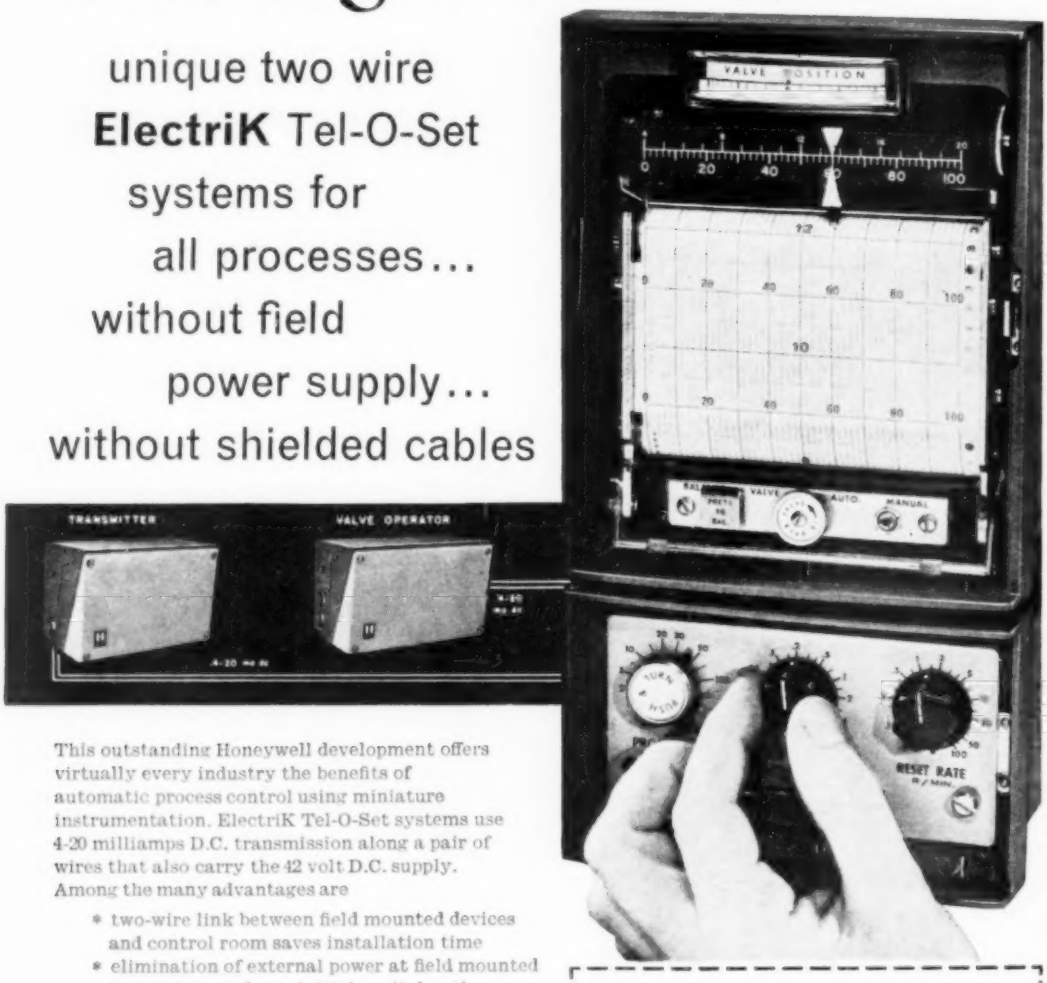

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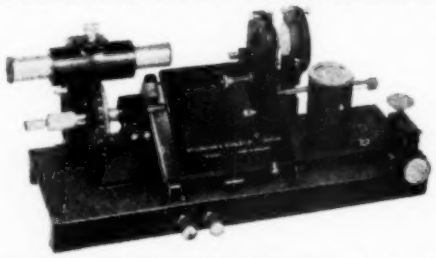

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SCIENCE IN WEST AFRICA

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The West African Science Association is formed by the Science Associations of Ghana, Nigeria and Sierra Leone, membership being open to any other scientific worker in any other country or territory in West Africa—including the French-speaking territories. Its purpose is to provide a forum for discussion, by scientists from all parts, of their common problems and to emphasize to public and Governments alike the fundamental importance of science and technology in the development of these areas.

This meeting had an additional significance, for it was the first major international scientific conference to be held in independent Nigeria. It was held, fortunately, at a time when much of the initial exuberance of political liberation had died down and it was possible to assess the problems ahead in a relatively sober atmosphere. This is important, for there is a real danger of complacency, a tendency to confuse the terms 'freedom' and 'prosperity'—not surprising, perhaps, when one sees the amazing transformation in Lagos, the modern buildings, the hotels, the new roads.

The generation of a potentially powerful African State with a seat in the United Nations Organization is no small thing. Perhaps under different conditions the nations would be little disturbed by the emergence of an independent Nigeria; but with a world divided into separate and mutually distrustful camps the result is a great deal of outside interest arising not from any deep-seated and humanitarian concern, nor from the prospects of great financial reward, but for purely political considerations. Capital from outside is available for many purposes; but it is a capital investment based not on sound economic principles but on political expediency.

These points are made merely to emphasize that Nigeria and Ghana—to mention the two territories with which we are more concerned in this context—are passing through a 'honeymoon' period. It is now, or possibly never, that they must take their chance. Capital must be spent wisely if wise development is to occur. Capital wasted now will, in the future, be merely a monument to an opportunity lost.

It may seem surprising that a meeting of scientists should concern itself with such matters. In fact, the meeting as such did not. But it was obviously the background against which much of the discussion took place, for the West African scientist is acutely concerned with the direction of future development, and a meeting such as this gives the best possible picture of the problems.

To one observer, at least, from all the papers and discussions emerged the impression that of all West Africa's problems none was more urgent than the matter of health and feeding. It is easy, in this apparently happy, cheerful community, to forget the grim realities behind. It is easy to forget that half the children born never live to adult life, that even among the adult population, disease extracts a dreadful toll. This would not be quite so bad if we did not already know enough to reduce these figures drastically. But all major health schemes are expensive, and the fact must be faced that West Africa simply cannot afford to keep its children alive. Even so, merely to keep children alive is not enough. They must be fed properly. Nigeria, though it is one of the most densely populated parts of the whole continent, is still a territory with vast, under-populated, undeveloped tracts of land. It is theoretically capable of maintaining a very much higher population. The other territories of West Africa are in a similar state—a great potential of food given over at present to the tsetse fly and incredibly inefficient farming methods.

The development problems implied in all this are, of course, many-sided. There are economic and social problems as well as technological problems—and, of course, educational problems are a vital part of the whole picture. But this meeting was concerned primarily with the technological—including the medical—problems involved. One gained an impression of advancing knowledge on all fronts. On the medical side it was made abundantly clear what modern knowledge properly applied could achieve. On the agricultural side there was an impression of slow advance. The tsetse fly is still unconquered, but it is clearly in retreat. For the rest, it is a matter now, not so much of more research, as of funds to apply what is already known, and to pay the technologists and scientists who will be needed.

Development is admittedly a total thing. For a nation really to emerge it needs far more than freedom. It needs schools, universities, cities—but above all it needs a reasonable expectation of life for its inhabitants and food to feed them. There is a most urgent need for the limited capital available to be well spent. Office blocks and handsome government buildings are no solution; they have their value, but one suspects that many of them are merely testimony to the validity of Parkinson's law—and these territories cannot afford Parkinson's law.

The suggestion was made—and endorsed enthusiastically—that a Scientific and Economic Advisory Council be set up as a matter of urgency, the task of which would be to advise the Government on the problems of development and how best to use the amount of money available. This would be a start—but even more necessary is a radical reappraisal of values; the vital role of science and technology is still not appreciated. The economic and social status of

the scientist still lags far behind that of many professions—and the lot of the science teacher, that most critical member of any modern community, is pitiful. (These remarks probably apply equally to Europe, even to America, but these countries are grown up and are at liberty to commit technological suicide if they wish.) To Africa, technological advance is not just a matter of keeping ahead of, or level with, or catching up with other countries—it is a matter of survival, not in some hypothetical future war but now.

The meeting which prompted these musings made it abundantly clear that scientific workers in West Africa are fully aware of all that has been said. They feel deeply their responsibilities to the future development of these territories. But they are also acutely aware of the difficulties. Scientists, technologists, science teachers are pitifully few in number and, relative to other professions, underpaid. There is far too little money forthcoming for the vitally important land development schemes which have been mooted, for the damming of rivers, for the intensive campaigns against the tsetse fly, for all the other necessary adjuncts to land development. There are the competing claims of industrialization. But this apart, a great deal of what is available would seem to be diverted at present into non-essential projects.

In Nigeria, at least, the Science Association has begun to face up to its wider responsibilities. It is not just a forum for the holding of yet another conference. It has a vital task in the education of the general public and of the Government. It is probably the only body in Nigeria with the machinery to drive home the basic fact that economic progress depends on technological progress. It has begun its task with vigour, but whether or not it will succeed in instilling the necessary sense of urgency remains to be seen.

UTILIZATION OF NITRATE BY MICRO-ORGANISMS

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INTENSIVE work on various physiological and biochemical aspects of the assimilation and dissimilation of nitrate by micro-organisms and higher plants has been undertaken in many laboratories. We now present a synthesis of the results in an attempt to clarify the present position in regard to the mechanism of the utilization of nitrate by micro-organisms.

Many micro-organisms and higher plants utilize nitrate-nitrogen, and the overall process whereby nitrate is reduced to ammonia with the subsequent formation of amino-acids, protein and other nitrogenous cell constituents is known as 'nitrate assimilation'. Under certain conditions, however, several micro-organisms can use nitrate or some of its reduction products as terminal hydrogen acceptors in place of oxygen. This process has been called 'nitrate respiration' by Sato[1] or 'dissimilatory nitrate reduction' by Verhoeven[2]. A similar process has been described in higher plants[3].

Many classifications have been proposed for the various types of nitrate reduction, but none has been entirely satisfactory. Jenson[4] suggested five categories according to the products of the reaction, whereas Verhoeven[2,5] differentiated between three types of nitrate reduction as follows: (1) *assimilation*, in which nitrate is reduced only for the building up of cell materials; (2) *incidental dissimilation*, in which nitrate acts as a non-essential hydrogen acceptor; (3) *true dissimilation*, in which nitrate acts, at least under certain conditions, as the essential hydrogen acceptor which enables the organism to grow. The separation of incidental and true nitrate dissimilation does not seem to be of great value and has only a teleological significance. Organisms which can carry out incidental dissimilation are those that have a fermentative respiration when both oxygen and nitrate are limiting factors. Thus, Verhoeven[5] showed that his strain of *Escherichia coli* produced large amounts of lactic and succinic acids under anaerobic conditions, but in the presence of either nitrate or oxygen complete oxidation to carbon dioxide occurred. Japanese workers[6,7] have classified nitrate-reducing organisms on the basis of the behaviour of their cytochromes towards nitrate. This is not now satisfactory since in *Neurospora crassa* and *Escherichia coli* an iron system appears to be required for the dissimilatory nitrate reductase but not for the assimilatory enzyme. We propose that nitrate reduction may be best considered under two headings: (1) *nitrate assimilation*, in which the end products are nitrogenous cell constituents; (2) *nitrate respiration* or *nitrate dissimilation*, in which nitrate is used instead of oxygen, usually under anaerobic conditions, as the terminal hydrogen acceptor. Denitrification may be regarded as a special case of nitrate respiration and is defined as the production of nitrogen gas or the oxides of nitrogen by the reduction of nitrate, nitrite or any other suitable intermediate.

Suggested Intermediates

Some of the compounds which are of interest in the intermediary metabolism of nitrate are shown in Table 1. Gayon and Dupetit[8] presented equations for the overall process of denitrification, but recognized only nitrite as an intermediate. Franzen and

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Table 1. Suggested Intermediates in Nitrate Reduction

Oxidation-reduction state of nitrogen atom	Formula	Compound
+5	NO_3^-	Nitrate
+4	NO_2	Nitrogen dioxide
+3	NO_2^-	Nitrite
+2	NO	Nitric oxide
	$N_2O_2^=$	Nitrohydroxylamate
	(NOH)	Nitroxyl
+1	N_2O	Nitrous oxide
	$N_2O_2^=$	Hyponitrite
	$NO_2 \cdot NH_2$	Nitramide or imido nitric acid
	$NH(OH)_2$	Dihydroxyammonia
0	N_2	Nitrogen
	OH.NH.NH.OH	Dihydroxyl hydrazine
−1	NH_2OH	Hydroxylamine
−2	$H_2N.NH_2$	Hydrazine
−3	NH_4^+	Ammonia

Lohmann[9] and Beijerinck and Minkmann[10] compiled comprehensive lists of possible products of nitrate reduction, but Kluyver and Donker[11] were the first to draw up a scheme for the stepwise reduction of nitrate to nitrous oxide and nitrogen gas. Since then, many pathways have been suggested, based on the assumption that reduction proceeds via a number of two-electron steps. The Delft school[2,5,12] have been particularly active in this field and have presented schemes involving complex molecular re-orientation at the hyponitrite-level of oxidation. Nicholas[12] suggested that nitrate assimilation proceeds according to the following pathway :

$$NO_3^- \longrightarrow NO_2^- \longrightarrow N_2O_2^= \longrightarrow NH_2OH \longrightarrow NH_4^+$$

Nitrate. Gayon and Dupetit[8] demonstrated that nitrite is the first product of nitrate reduction. Quastel, Stephenson and Whetham[14] found that *Bacterium coli* produced nitrite when grown anaerobically ; nitrite has since been identified as a product of nitrate reduction in bacteria, fungi and higher plants[6,15]. The agronomic importance of nitrate reductase activity in maize plants has been demonstrated by Hageman and Flesher[16].

The sequence of electron transfer during nitrate reductase activity by the purified enzyme from *Neurospora crassa* has been shown to be[13] :

$$\text{TPNH} \longrightarrow \text{FAD} \longrightarrow \text{Mo} \longrightarrow NO_3^-$$

(2,3′, 6-trichlorophenol indophenol)

A similar molybdo-flavoprotein system has been described in the yeast *Hansenula anomala*[17] and in higher plants[18].

Both molybdenum and cytochrome have been shown to participate in nitrate reduction by denitrifying bacteria[19]. The sequence of electron transfer to the alternative hydrogen acceptors oxygen and nitrate in whole cells of *Pseudomonas aeruginosa* is :

DPNH → FAD → cytochrome *c* → nitrate reductase (Mo) → NO_3^-

cytochrome *c* → cytochrome oxidase → O_2

Sadana and McElroy[20] proposed a similar scheme for nitrate reduction in *Achromobacter fischeri* (≡ *Photobacterium fischeri*), but claimed that molybdenum was not involved. Although they grew the bacteria in peptone medium without the addition of molybdenum, it is unlikely that their cultures were in fact deficient in the micronutrient since no purification methods were used. Thus, further work is required to determine whether *Phytobacterium fischeri* requires molybdenum for the reduction of nitrate.

Many schemes have been postulated for nitrate reduction in *Escherichia coli*, and Taniguchi and Itagaki[21] have recently obtained a homogeneous molybdo-protein which reduces nitrate with cytochrome b_1 as the electron donor. It is probable that the different pathways suggested by various workers using this organism can be explained by the different hydrogen donors in the nitrate reductase assay and by the varied conditions under which the organism was grown. Thus the preparations have probably all contained the same terminal nitrate reductase (that is, the molybdo-protein) with either succinic dehydrogenase[22], lactic dehydrogenase[22], diaphorase[23] or quinone reductase[24] as the penultimate hydrogen-donating system. Table 2 illustrates that differences also occur between strains. Thus *E. coli* (*Pf*) can dissimilate nitrate under anaerobic conditions, and both iron and molybdenum deficiencies reduce the nitrate reductase activity. Nitrite accumulates, and the glucose in the medium is almost entirely oxidized to carbon dioxide. Strain *B.L.A.*, however, can utilize nitrate as the sole nitrogen source for growth[25], but not as a hydrogen acceptor during anaerobic respiration. In this case, iron deficiency has no effect on nitrate reductase activity, indicating that a cytochrome system is not involved. The metabolism of this strain under anaerobic conditions is fermentative, and organic acids accumulate in the medium.

Table 2. Growth of *Escherichia coli* under Anaerobic Conditions

The cells were grown in a medium containing both NH_4^+ and NO_3^- ions (ref. 23) under anaerobic conditions for 24 hr. at 37° C.

Strain	*B.L.A.**	*Pf*†
Nitrate reductase activity of iron-deficient cells as a percentage of the activity of normal cells	103	42
Nitrate reductase activity of molybdenum-deficient cells as a percentage of the activity of normal cells	51	48
Carbon dioxide production during growth	+	+ + + +
Nitrite ion in the culture medium	±	+ + + +
Lactic acid in the culture medium	+ + + +	+ +
Succinic acid in the culture medium	+ + + +	−

* Strain *B.L.A.* was derived from strain *B.*, kindly supplied by Dr. R. Herriott, Biochemistry Department, Johns Hopkins University School of Hygiene and Public Health, Baltimore, by sub-culturing it on nitrate medium.

† Strain *Pf* was a gift from Dr. J. Erkama, Biochemistry Department, University of Helsinki.

It has been suggested that cytochromes participate in nitrate reduction only in the dissimilatory process[19,26]. This is confirmed by the results in Table 3, which show that iron deficiency depressed nitrate reductase activity only in organisms dissimilating nitrate under anaerobic conditions. In contrast to this, molybdenum deficiency invariably decreased nitrate reductase activity under either aerobic or anaerobic conditions. It is noteworthy that a deficiency of either iron or molybdenum reduced the enzyme activity of *Rhizobium japonicum* extracted from soy-bean nodules[27].

Table 3. Effects of Iron Deficiency and Aeration on the Nitrite Reductase Activity of Micro-organisms

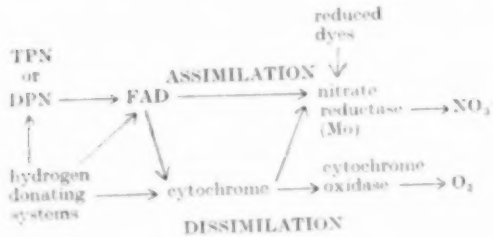
The enzyme activities of homogenates prepared from iron-deficient cells are given as percentages of those of homogenates prepared from normal cells grown under the same conditions of aeration

Organism	Nitrogen source in culture medium	Condition of growth	
		Anaerobic	Aerobic
Clostridium pasterianum (W–S)	Nitrate	122	*
Escherichia coli (B.L.A.)	Nitrate + ammonium	103	108
Escherichia coli (Pf)	〃 〃	42	106
Micrococcus denitrificans (N.C.I.B. 8944)	〃 〃	28	†
Neurospora crassa (Em 5297a)	Nitrate	45	130
Pseudomonas aeruginosa (N.C.I.B. 8704)	Nitrate + ammonium	40	†

* Obligate anaerobe which can use neither oxygen nor nitrate as a terminal electron acceptor.

† The denitrifying organisms have negligible nitrate reductase activity under aerobic conditions.

These results suggest that a generalized scheme for electron transport during microbial nitrate reduction can be constructed as shown in scheme 1.



Scheme 1. Alternative pathways of electron transfer to nitrate and oxygen in micro-organisms

This emphasizes the homology of nitrate dissimilation and aerobic respiration, first suggested by Gayon and Dupetit[8]. Takahashi, Taniguchi and Egami[28] have suggested that dissimilatory nitrate reduction is coupled to phosphorylation, and this seems to be probable in view of the similarities in the electron-transfer sequence during respiration with either oxygen or nitrate as the terminal acceptor, and the large change in free energy ($-\Delta F$ approximately 40 kcal./mole) during the reduction of nitrate by reduced diphosphopyridine nucleotide. It is feasible that the coupling reaction might provide a control mechanism whereby a cytochrome system is involved in nitrate dissimilation and not in nitrate assimilation.

Similar alternative hydrogen-donating systems probably occur in higher plants. Thus, Mendel and Visser[29] suggested that the reducing power for nitrate reduction was of respiratory origin in the dark and of photosynthetic origin in illuminated leaves. Stoy[30] concluded that nitrate reduction in the light and dark "are identical in essential parts and that the only difference lies in the various ways in which the hydrogen donors, necessary for the nitrate reduction, can be generated".

Nitrite. Yamagata[31] found a nitrite reductase enzyme in cell-free extracts of *Bacillus pyocyaneus* and Taniguchi *et al.*[32] showed that extracts of *B. pumilus* reduced nitrite when reduced methylene blue was the electron donor. Nitrite reduction has also been demonstrated in species of *Azotobacter*, *Debaryomyces*, *Desulfovibrio*, *Escherichia* and algae (see refs. 5, 13, 25).

Nitric oxide has occasionally been observed as a product of denitrification[33,34], and it has now been identified as the immediate product of nitrite reduction during denitrification by *P. stutzeri*[35], *P. aeruginosa*[25,36] and *M. denitrificans*[25]. The product of assimilatory nitrite reduction has not previously been determined, although the enzyme has been studied in considerable detail[37]. Medina and Nicholas[38] suggested that hyponitrite was the first product of the reduction, but Nicholas and Jones (unpublished results), using a chromatographic technique[39], could not detect it during nitrite reduction by the purified enzyme from *Neurospora*. It is doubtful, however, whether this technique was sufficiently sensitive to detect the small amounts of product expected. The results obtained by Walker[40] in this laboratory suggest that nitric oxide is formed during nitrite reduction by the purified *Neurospora* enzyme.

The assimilatory nitrite reductase purified from *N. crassa*[37] and the dissimilatory enzyme from *P. aeruginosa*[36] appear to be very similar, since they are both flavoproteins which require copper, iron and sulphydryl groups for maximum activity. Walker and Nicholas[36] and Yamanaka *et al.*[41] have shown that the *Pseudomonas* enzyme has cytochrome oxidase activity, but this does not appear to be its primary function, since nitrite is a much more efficient electron acceptor than is oxygen.

Iwasaki and Mori[42] claimed that nitrite and hydroxylamine could react enzymatically to give nitrous oxide and nitrogen, but this could not be confirmed in this laboratory[25] or by Asano[43].

Recent work[44] makes it probable that the disappearance of nitrite noted in soy-bean leaves by Nason *et al.*[45] may not have been due to a nitrite reductase. There is little doubt, however, that a nitritase enzyme exists in plant tissue, since nitrate can be utilized as the sole nitrogen source and nitrite is the only known product of the nitrate reductase enzyme. Butt and Beevers[46] suggested that nitrite is reduced by reduced triphosphopyridine nucleotide generated in the pentose phosphate pathway.

Nitric oxide. We have recently produced evidence that nitric oxide, or a compound with which it equilibrates, is an intermediate in both assimilatory and dissimilatory nitrate reduction[47]. There are two main lines of evidence: (1) nitric oxide is the immediate product of nitrite reduction in *Neurospora* and in several denitrifying bacteria; (2) nitric oxide reductase activity is found in micro-organisms and higher plants which are actively reducing nitrate, but the enzyme is absent or much reduced in organisms grown on ammonium-nitrogen only.

Inhibition of hydrogenase activity by nitric oxide *in vitro* has been noted in species of *Azotobacter*, *Clostridium*, *Escherichia* and *Hydrogenomonas*[47,48], but this is unlikely to have very great significance *in vivo* since nitric oxide probably has only a transient existence in association with the enzyme; indeed, it is formed as the free gas rarely even by denitrifying organisms[47]. This is confirmed by our observations that nitric oxide can act as the acceptor during hydrogenase activity in extracts of *M. denitrificans* and only at relatively high concentrations (greater

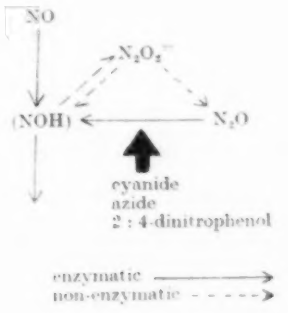
than 0·05 atmosphere) is it inhibitory. We have also confirmed the observations of Keilin and Hartree[19] than nitric oxide can form a complex with cytochrome *c*, but it is doubtful whether this is of physiological significance.

Hyponitrite, nitroxyl and nitrous oxide. Many workers[2,11,13,50] have suggested that nitrate reduction involves an intermediate at this level of oxidation. Nitroxyl, hyponitrite, nitrous oxide, nitramide and dihydroxyammonia have all been postulated, but experimental evidence for any of these is scanty.

Assimilation of hyponitrite has been reported in *E. coli*[51] and in *N. crassa*[18]. The instability of hyponitrite[52,53] makes experimental work and the interpretation of results difficult. We have confirmed that hyponitrite decomposes rapidly at physiological *p*H, and the presence of whole cells or cell-homogenates of *P. aeruginosa* did not change the rate of non-enzymatic production of gas[25]. This finding is in agreement with the results of Allen and van Niel[52] with *P. stutzeri* and of Kluyver and Verhoeven[54] with *P. aeruginosa* and *M. denitrificans*. These results, however, do not rule out hyponitrite as an intermediate, since it could have a transient existence in association with enzyme surfaces.

Several workers have reported that nitrous oxide can be reduced to nitrogen gas or ammonia by bacteria[2,51,52,54,55]. It is unlikely, however, that nitrous oxide is a usual intermediate in denitrification, since nitrogen production from nitrous oxide can be inhibited by levels of cyanide, azide or 2 : 4-dinitrophenol which have no effect on the rate of production of nitrogen gas from nitrite[52,55]. Experiments on simultaneous adaptation have produced conflicting results; but Sacks and Barker[55] using *P. denitrificans*, and McNall and Atkinson[51] using *E. coli*, found that cells adapted to nitrate utilized nitrous oxide only after a lag period. It is likely that nitrous oxide is utilized *per se* since it is the formal anhydride of hyponitrous acid and dissolves in water to give a true solution[56].

These results can be integrated by assuming that a compound like nitroxyl (NOH), containing one nitrogen atom, is the intermediate in nitrate reduction, and that this is in equilibrium with hyponitrite which can decompose to give nitrous oxide. A further adaptive enzyme is necessary to utilize nitrous oxide. This is illustrated in scheme 2, and is similar in outline to that presented by Lees[57] for the nitrification process.



Scheme 2. Some intermediates during the assimilation and dissimilation of nitrate

The scheme is supported by the following lines of evidence: (1) Nitrous oxide has frequently been reported as a product of denitrification[9,58]. Recent work by Delwiche[59] makes it probable that nitrous oxide is formed non-enzymatically when a compound at the nitroxyl level of oxidation accumulates. (2) The occasional reports of simultaneous adaptation to nitrate and nitrous oxide[52,54] could be caused by induction of the enzyme utilizing nitrous oxide by small amounts of the gas formed during growth. (3) The existence in solution of hyponitrite or nitrous oxide explains the nitrogen 'losses' observed by several workers[60], who measured only nitrate, nitrite, nitrogenous gases, ammonia and cell nitrogen during denitrification. (4) This scheme explains the utilization of hyponitrite, since it would exist in equilibrium with nitroxyl and would also produce nitrous oxide which could be utilized. (5) The true intermediate is likely to contain only one nitrogen atom, as do the other intermediates. A compound such as hyponitrite would involve the consecutive formation and breakage of an N–N bond and this, although possible, is, from a consideration of the energy changes involved, unlikely.

Hydroxylamine. Verhoeven[2] detected hydroxylamine in the culture medium during dissimilatory nitrate reduction by *Denitrobacillus licheniformis* and the reduction of hydroxylamine to ammonia has been demonstrated in a number of micro-organisms[51,61].

Hydroxylamine reductases from *N. crassa*[13] and from *P. aeruginosa*[62] have been shown to be flavoproteins requiring manganese for activity. Kono and Taniguchi[63] have also implicated a cytochrome in reduction of hydroxylamine by a denitrifying *Micrococcus*. The Japanese workers concluded that "hydroxylamine reductase may have physiological meaning other than the mere reduction of hydroxylamine"[63]. This seems unlikely, since the product of the reduction has been shown to be ammonia[10,62], and we have demonstrated[25] that *P. aeruginosa* assimilates small amounts of nitrate-nitrogen (15 per cent of the total cell nitrogen) even while denitrifying actively in a peptone-nitrate medium.

Extracts of higher plants have been shown to oxidize hydroxylamine by means of a peroxidase system stimulated by manganese[64,65]. There is no evidence that this has physiological significance *in vivo*, although there have been reports that nitrate occasionally accumulates in detached leaves kept in the dark[30]. Cresswell and Hewitt[65] suggested that this system "may well provide a basis for the nitrification of hydroxylamine". This may be true for heterotrophic nitrification, for example, by *Aspergillus flavus*[66] (although even here it is of doubtful physiological significance), but is unlikely to apply to autotrophic nitrification by *Nitrosomonas spp.*, where the process is linked to a system yielding energy.

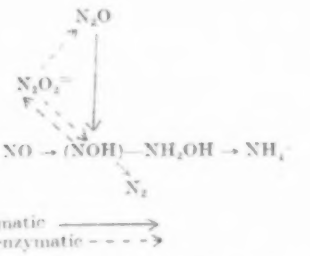
The oxime pathway for utilization of hydroxylamine appears to have little significance except as a detoxication mechanism (see the review by Nicholas[13]).

Aromatic compounds. It has been suggested that alternative or simultaneous mechanisms for reducing nitrate could involve aromatic nitro compounds. There is, however, little evidence for this[12,67]. Enzymes capable of reducing a range of aromatic nitro-compounds have been demonstrated[67,68], but

there is no evidence for enzymes responsible for the nitration of the benzene nucleus and this is an obligate step in any such hypothesis.

Common Pathways in Assimilation and Denitrification

The final products of nitrate assimilation are, by definition, nitrogenous cell components. During nitrate dissimilation, however, the following products can be formed: nitrite, nitric oxide, nitrous oxide, nitrogen, hydroxylamine or ammonia. The results already discussed show that the processes involved in both assimilatory and dissimilatory nitrate reduction are very similar. Thus, some of the intermediates have been shown to be the same, and the properties of the enzymes are alike. The assimilatory route has been described in detail previously[13], but it appears that it should now include nitric oxide as a likely intermediate. Schemes for nitrate dissimilation, and for denitrification in particular, have usually been complex[2], but we have shown that the sequence of intermediates may be similar to that in the assimilatory route, and both processes are presented in scheme 3.



Scheme 3. A pathway for the reduction of nitrate in micro-organisms

It is clear that in dissimilation of nitrate the rate of reduction of nitrate will be much greater than that in assimilation of nitrate, since in dissimilation the nitrate has a respiratory function. Some intermediates, which probably normally exist only as enzyme-bound complexes, may therefore accumulate. On this basis, it is clear that the products of nitrate dissimilation depend on the relative activities of the enzymes of the reductive sequence present in the organism. Thus, those organisms which produce large amounts of nitrite (for example, *E. coli*, *N. crassa*) have a very active nitrate reductase and little or no nitrite reductase activity. On the other hand, some organisms (for example, *B. licheniformis*[2]) produce ammonia during dissimilation, and here all the enzymes in the reductive sequence must be very active. Denitrifying organisms occupy an intermediate position; in a few cases nitric oxide is produced[24], and here the nitric oxide reductase is presumably less active than the nitrite reductase. Similarly, we have suggested how nitrous oxide is produced when the intermediate at the nitroxyl-level accumulates. Denitrification is an efficient form of dissimilation of nitrate in that the products are gaseous and toxic compounds such as nitrite do not accumulate in the medium. This may well have ecological significance. We have demonstrated that *P. aeruginosa* can assimilate nitrate-nitrogen even while actively denitrifying[25], but some denitrifying organisms require ammonium-nitrogen for growth[26,69]. In these cases it is likely that at least one of the later enzymes, probably hydroxylamine reductase, is absent. This is an analogous situation to the *Neurospora* mutants, which can reduce nitrate but not nitrite[70].

The homology of aerobic respiration and dissimilatory nitrate reduction has been pointed out already. That the aerobic process is more efficient is suggested by the following findings: (1) Proliferating bacteria denitrify only under anaerobic conditions, and aeration prevents the induction of the nitrate-reducing enzymes[19,20]. (2) Cell yield is usually lower in bacteria-dissimilating nitrate than in those grown aerobically[28,71]. This might be caused by the formation of a smaller number of high-energy phosphate bonds during the oxidation of carbohydrate substrates by nitrate than by oxygen, that is, a less efficient use of the energy sources. Confirmation of this idea can only come from a study of the extent to which phosphorylation is coupled to nitrate dissimilation. (3) Even cells possessing the nitrate-reducing enzymes use oxygen rather than nitrate as the terminal hydrogen acceptor[19,25,72]. Oxygen has no effect on the enzymes *per se*, but the cytochrome oxidase appears to be more efficient than the nitrate reductase in oxidizing the reduced cytochrome which is involved in the dissimilatory system.

Conclusions

The hypothesis presented here, which serves to link the assimilation and dissimilation of nitrate, is consistent with the data available at the present time. It also agrees with the concept of the "unity of biochemistry"[11,12], which suggests that if similar chemical reactions are carried out by different organisms, then the mechanisms involved are also likely to be similar. Thus, several unrelated organisms can dissimilate nitrate, and it is more likely that a process such as denitrification represents a fairly simple adaptation of a widespread existing system (that is, nitrate assimilation) rather than a *de novo* formation of an entirely different pathway. Similarly, it is probable that a closely related system for nitrate reduction exists in higher plants and, furthermore, the reverse process of nitrification may well involve the same intermediates.

It seems likely, therefore, that the process of nitrate assimilation follows the inorganic sequence to ammonia. Nitrate dissimilation appears to be merely an adaptation of the assimilatory pathway, partly by the intervention of cytochromes in the penultimate electron transfer sequence. Denitrification is a special case of nitrate dissimilation in which the main end-products are nitrogenous gases.

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Coggins identified the organic acids in the culture medium.

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THE EVOLUTION OF OVERDOMINANCE: NATURAL SELECTION AND HETEROZYGOTE ADVANTAGE

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HETEROSIS or hybrid vigour, inbreeding depression and the maintenance of balanced polymorphisms in natural populations have all been associated in one form or another with overdominance. The occurrence of overdominance may be viewed either as an intrinsic phenomenon or as the outcome of an evolutionary process, and in this article we shall argue for the latter possibility.

The term 'overdominance' is applied either when the heterozygote for two alleles at a locus, or more generally when the heterozygote for two genetically different but homologous sections of a chromosome, is superior in mean fitness to either homozygote. Heterosis, or hybrid vigour, on the other hand, is not defined in terms of such specific genetic situations. It describes the observation of a higher mean, with respect to a quantitatively varying character, for the hybrid between two more or less pure lines than for either pure line. When the quantitative character considered is not fitness, Dobzhansky[1] has suggested the term 'luxuriance' should be used instead of heterosis, so that heterosis may be taken to refer

specifically to an observed excess fitness of the hybrid. Overdominance may be a cause of heterosis; but the occurrence of heterosis does not imply the existence of overdominance.

Overdominance may also be a cause of the complementary phenomenon of inbreeding depression. The natural causes of heterosis and inbreeding depression have been the subject of much discussion. Some writers, notably Haldane[2] and Lerner[3], have pinpointed overdominance as the basic underlying mechanism, and so have been led to assume an intrinsic advantage for heterozygous genotypes. On the other hand, Fisher[4] and especially Mather[5] have attached overriding importance to non-allelic gene interactions as a cause for heterosis and inbreeding depression. There is on this view no longer a need to attach any intrinsic importance to the phenomenon of overdominance. We shall first of all review the evidence for the occurrence of overdominance and then show how it may evolve.

Causes of Inbreeding Depression

One of the simplest explanations for inbreeding depression is the accumulation of deleterious recessives. However, the loss in vigour from this cause has been shown to be no more than 1–5 per cent[4,6], whereas heterosis of the order of 20 per cent is quite common. On the other hand, the calculation by Fisher[7] of the loss of reproductive value on inbreeding a random-mating population polymorphic for an overdominant pair of alleles, and similar calculations by Haldane[8] and Crow[6], show that overdominance at a comparatively small number of loci might be sufficient to explain observed levels of heterosis and inbreeding depression. There is, however, little direct evidence that supports the simple view of intrinsic overdominance, or 'heterosis *per se*' as it is frequently called, as the basic underlying mechanism. As Mather[5] points out, the occurrence of overdominance in relation to hybrid vigour has scarcely, if ever, been proved, for it is difficult to distinguish from non-allelic gene interaction. Thus, Schuler and Sprague[9], for example, found no evidence in maize for overdominance with respect to specific genetic markers. Further, Jinks[10], using di-allele crossing techniques, found overdominance always in association with non-allelic gene interactions. It has also been shown by Williams[11] that heterosis for a complex character may arise through multiplicative interactions between its various components.

Overdominance, Balanced Polymorphisms and Linkage

Overdominance was shown by Fisher[12] to be a theoretically necessary condition for a balanced polymorphism in a random mating population, when the selective values remain constant. Although, when selective values vary, it is possible to construct models which retain two alleles in a random mating population without overdominance[13,14], it is probable that most of the known cases of balanced polymorphisms are, in fact, associated with the occurrence of overdominance. The association between polymorphism and close linkage was first pointed out by Fisher[15]. One of the first examples of a probable complex of closely linked genes was discovered by Ernst[16] in the distylic polymorphism of some species of *Primula*. Further, Fisher[7] showed how interaction between two or more factors could lead to the tightening of linkage between them. It seems likely, therefore, that we can explain the evolution of closely linked complexes of genes, such as occur in *Primula*, by the accumulation of favourable modifiers linked to a segregating polymorphic locus. The importance of linkage and non-allelic interaction in the building up of complex polymorphic loci has been stressed by Sheppard[17] and Mather[5]. More recently, Clarke and Sheppard[18–20], in a series of papers on mimicry in various African species of *Papilio*, have provided convincing evidence that the mimetic forms are most probably controlled by the various alleles of a 'super-gene' which has evolved in this way. There seems to be little doubt that such polymorphisms are clear examples of an association between overdominance and linkage between interacting genes.

The concept of the balance of polygenic combinations was first developed in a classic paper by Mather[21], although it was, perhaps, foreshadowed by Fisher[7] when writing on "simple metrical characters". On the assumption that natural selection favours intermediate phenotypes, gametic combinations which are well 'balanced' with respect to high and low factors will be continually selected at the expense of poorly balanced combinations which give rise to extreme values. The poorly balanced gametes will be continually produced from well-balanced gametes by recombination so that natural selection will favour closer linkage between factors occurring in a well-balanced combination, or combinations of factors which are already more closely linked. In outbreeding species, selection may thus be expected to cause the accumulation of chromosomes heterozygous for linked balanced polygenic combinations which, although phenotypically uniform, release genetic variability by recombination.

In the simple case of two segregating loci A–a, B–b with A, B acting in one direction, and a, b acting in the other, natural selection will favour the balanced repulsion heterozygote Ab/aB. Evidence for the importance of recombination in releasing significant genetic variability comes from the artificial selection experiments of Mather and Harrison[22], and more recently from the striking phenomenon of repeated response to selection described by Thoday and Boam[23]. More specific evidence for the occurrence of linked balanced complexes in a disruptive selection experiment is given by Gibson and Thoday[24]. The importance of linked interacting gene complexes is also emphasized by experiments with *Drosophila* obtained from natural populations, such as those of Dobzhansky and Levene[25] and of Spiess[26]. There is, perhaps, an analogy between the balanced polygenic combination and the balanced lethal heterozygote and, as pointed out by Mather[5], the former as much as the latter are clearly examples of overdominant situations in the more general form as defined at the beginning of this article.

This brief review of the evidence for the occurrence of overdominance shows that it is most unlikely to be a phenomenon commonly associated with just a single pair of alleles differing at only one genetic site. Even in its simplest form, in a balanced polymorphism, overdominance is closely associated with linkage between interacting genes, and more generally

is dependent to an appreciable extent on the genetic background. The dependence on the genetic background is clearly illustrated by the work of Levene, Pavlovsky and Dobzhansky[27], and Dobzhansky[28] with various chromosome rearrangements in *Drosophila pseudo-obscura*, which are frequently polymorphic in natural populations.

Evolution of Dominance

The dependence of overdominance on the genetic background bears a striking resemblance to the similar situation with respect to dominance in such cases as the crinkled dwarf mutant in cotton, which was the first example used by Fisher[29] as evidence for his theory of the evolution of dominance. This theory relates to the common occurrence of the dominance of a wild-type gene over rare deleterious alleles. Since the deleterious allele is rare, it will occur much more frequently in a heterozygous than in a homozygous state, if it is assumed that the heterozygote is less fit than the wild-type homozygote. Fisher argued that modifiers affecting the deleterious mutant would therefore be selected almost entirely for their effect on the heterozygote, and that selection of such modifiers would gradually lead to the resemblance of the mutant heterozygote and the wild-type homozygote. The selection for modifiers will depend on the frequency of the heterozygote, and so increase as its frequency increases, but selection will always be slow so long as the mutant is rare. This will be the case so long as the mutant homozygote is at an appreciable disadvantage. As pointed out by Fisher[30], selection for modification of the mutant homozygote will be slow until the heterozygote is fairly frequent "except in so far as some such an effect has already been produced by the selective modification of the heterozygote". Fisher's theory of the evolution of dominance was criticized by Wright[31] and Haldane[32] soon after its first publication, principally on account of the very slow rate at which modifiers of the mutant heterozygote would be selected. However, subsequent experimental evidence for the breakdown of dominance on outcrossing such as in the work on cotton[33] or in Ford's[34] work with *Triphæna comes* (*Hb*), and more recently in the work of Clarke and Sheppard[19,20] in the mimicry alleles in *Papilio* species, leaves little doubt that, at least in a fair proportion of cases, dominance is an evolutionary phenomenon and its expression depends on the genetic background.

It was pointed out by Fisher[15] that if, for any reason, the heterozygote occurs in appreciable proportions, such as is the case in a balanced polymorphism, evolution of dominance may occur much more rapidly than in the modification of the dominance of an ordinary deleterious mutant. This will, however, apply only to such genetic factors as affect external appearance, where it may be an advantage for the heterozygote to resemble one or other homozygote, but the basic polymorphism is determined by some constitutional effect of the factor other than that on external appearance. It can be shown (Bodmer, unpublished) that modifiers of the three genotypes, formed by two alleles at a locus, occurring in a balanced polymorphism, will be selected according to the prevailing genotype frequencies. Since in such a situation the 'mutant' homozygote is no longer rare, there is not the same differential selection for modifiers of the heterozygote as in the situation to which Fisher originally applied his theory. However, during the initial stages of progress of an advantageous gene, the gene will occur principally in heterozygotes and there may then be opportunities for differential selection of modifiers of the advantageous heterozygote[35]. This is a situation not apparently envisaged by Fisher in his original development of the theory of the evolution of dominance, but one which is exemplified in the classic work of Kettlewell[36] on the industrial melanic forms of the moth *Biston betularia*.

Increase of Newly Occurring Genes

The conditions under which a newly occurring gene will become established have been investigated by Bodmer and Parsons[35] for three specific genetic systems. Their general conclusion was that the newly formed heterozygote must be at an advantage in outbreeding species, and that the measure of the advantage needed to establish the gene decreases as the amount of inbreeding increases. Thus, consider the simple case of a new allele A being introduced into a population which is predominantly aa. Let the frequency of the allele A be q, and of a be p where $p + q = 1$, and suppose the amount of inbreeding to be measured by a constant inbreeding coefficient F. Then if the viabilities of the genotypes AA, Aa, and aa are respectively a, h and b, the frequencies of the three genotypes after selection will be:

$$\begin{aligned} &AA \quad a(q^2 + pqF)/T \\ &Aa \quad 2hpq(1 - F)/T \\ &aa \quad b(p^2 + pqF)/T \end{aligned}$$

where T is such that the frequencies after selection add up to unity. If, initially, A is rare, then q is small and neglecting terms in q^2 the condition that the frequency of A should increase is:

$$aF + h(1 - F) > b$$

and this is the condition for the gene A to become established in the population. When $F = 0$ and there is random mating this gives $h > b$, which is simply the condition that the new heterozygote should be fitter than the prevailing homozygote. When $F = 1$ and there is complete selfing we have $a > b$, and this means that the new homozygote must be fitter than the old homozygote. As F goes from 0 to 1 for increasing amounts of inbreeding, the relative importance of the heterozygote viability h, in determining the initial increase of the gene A, diminishes. Thus the importance of initial heterozygote advantage is entirely a function of the breeding system.

Evolution of Overdominance

Now Haldane[37], in a paper on the theory of selection for melanism in moths, has given an elegant calculation for the total number of heterozygotes produced in the course of the substitution of a new advantageous gene. He argues that if this total number of heterozygotes is H times the average population size in any one generation, then selection for modifiers of the heterozygote will be equivalent

to the effects of H generations of selection on a population consisting entirely of heterozygotes. He later qualifies this statement, however, by saying that when the viabilities of the heterozygote and the new homozygote are equal (and, of course, greater than that of the old homozygote) "there is no selective pressure tending to select modifiers of heterozygotes".

This statement is followed up in his paper on "The Cost of Natural Selection"[38], where he considers the number of "selective deaths" as an effective measure of the selection for modifiers of any particular genotype. On this premise, when there are no differences in fitness between genotypes, there can be no selection of modifiers which improve the fitness of any one genotype. It is clear that such a model excludes the possibility of evolving overdominance, for once the viability of the heterozygote has been selected up to that of the new advantageous homozygote, Haldane would argue that there could be no further differential selection of modifiers improving the heterozygote viability. This situation arises from his assumption that on the whole a species "can only maintain its numbers by utilizing its reproductive capacity to the full", and so taking as his basic model a situation in which there is a deterioration in the environment causing a lowering of the mean fitness. Selection of a new gene in this environment is then acting only to return the mean species fitness to its former level. This does not allow the possibility of selection for a gene increasing the mean fitness without any prior deterioration of the environment. It is surely necessary to have a theoretical model which can allow for a positive evolutionary change of this sort. As Thoday (personal communication) has suggested to us, Haldane's basic assumptions do not take into account "the cost of living".

In his original calculations on the theory of dominance, Fisher[30] expressed the selection for modifiers of the heterozygote in terms of the fraction of the ancestry of future generations ascribable to heterozygotes or, as Haldane[39] called it, their "ultimate reproductive value". The calculation assumes a steady state with respect to the rare mutant, the frequency of heterozygotes being maintained by recurrent mutation. In this case the ultimate reproductive value of a heterozygote remains the same, at least during an interval of time when the heterozygote viability has been improved only a little. There is no clear parallel to this concept when we consider the progress of an advantageous gene in an outbreeding population. As we have shown here, such a gene must start off by having an advantage in the heterozygote over the prevailing wild-type homozygote. Even if the new homozygote is initially fitter than the heterozygote, when the new gene is rare and so occurs principally in heterozygotes, the contribution of heterozygotes to future ancestry is still much more than that of homozygotes. However, as the gene frequency increases, and so the proportion of homozygotes relative to heterozygotes increases, this situation will change and homozygotes will end up by contributing much more, in total, to future ancestry.

Following Haldane[37], it is possible to calculate the total number of heterozygotes Aa and homozygotes AA produced as a new advantageous gene increases in a population consisting initially mostly of the genotype aa. By weighting the frequency of a genotype in any generation with its contribution, in terms of reproductive value, to the subsequent generation it is also possible to calculate the total contribution of reproductive value made by the genotypes Aa, AA during the evolutionary progress of the new gene A. Assuming viabilities $1+S_1$, $1+S_1 - S$ and 1 for the genotypes AA, Aa and aa respectively, we have calculated the total number, or total reproductive value, contributed by the genotypes AA, Aa as the gene frequency of A increases from q_0 to q_1 for a series of different values of S_1 and S. If we assume that q_0, the initial frequency of A, is small, then these contributions depend largely on $1/S_1$ (where S_1 is the excess viability of AA over aa) for any given value of q_1. Table 1 shows the number of heterozygotes Aa produced by the time A has reached gene frequencies ranging from 0·1 to 0·9 for two different sets of viabilities. In the first case $S_1 = 1$ per cent and $S = 0$, so that A is fully dominant, and in the second case $S_1 = 5$ per cent and $S = 2{\cdot}5$ per cent, so that A is now an 'additive' gene with respect to fitness. The actual numbers in Table 1 represent multiples of the population size (assumed constant) in any generation. The ratio of the number of Aa as compared with the number of AA is given in the last column of Table 1 to the nearest whole number. This ratio is more or less independent of the viabilities S_1 and S, and appears to be a characteristic of the pattern of increase of a new gene in a random-mating diploid population.

Table 1

q_1	No. of heterozygotes Aa: $S_1 = 1$ per cent, $S = 0$	No. of heterozygotes Aa: $S_1 = 5$ per cent, $S = 2{\cdot}5$ per cent	Ratio of heterozygotes Aa to homozygotes AA
0·1	21·3	8·2	37
0·2	45·1	16·4	17
0·3	72·0	24·6	10
0·4	103·2	32·8	7
0·5	140·0	41·0	5
0·6	185·1	49·2	4
0·7	243·2	57·4	3
0·8	325·1	65·6	2
0·9	465·1	73·8	1

where q_1 is the frequency of the 'new' gene A and the viabilities of AA, Aa, aa are $1+S_1$, $1+S_1-S$, 1 respectively.

It is clear that when the frequency of A is small far more heterozygotes than homozygotes have been produced and this excess is still appreciable when q_1 is 40 per cent or even 50 per cent. Thus, if modifiers can have been selected at all in the time taken to reach this gene frequency, they will have been selected much more for their effect on the heterozygote Aa than on the homozygote AA. It is the total number of heterozygotes produced, not the number which have died selectively, which gives an approximate measure of the number of equivalent generations of selection available for a population consisting entirely of heterozygotes.

It can be shown that the difference between the total number produced and between the total contribution of reproductive value is generally only of the order of magnitude of the gene frequency. The details of these calculations will be published elsewhere. The results provide a theoretical basis for the statements by Mather[5,40] that outbreeding species are exposed to natural selection in a predominantly heterozygous condition. It is, of course, clear that as soon as modifiers have increased the

fitness of the heterozygote over that of both homozygotes, a balanced polymorphic situation will be achieved in which the heterozygote is permanently maintained in the population.

In a further calculation, Haldane[37] has obtained an expression for the increase in frequency of an independent dominant modifier of the heterozygote, throughout the course of the increase of the advantageous gene. In our notation, the modifier would increase in frequency by a factor :

$$F = \left(\frac{S_1 - S}{S}\right)^{2\mu/(S_1 - 2S)}$$

where μ is the advantage conferred on the heterozygote by the modifier. Haldane considers only the case $\mu = S$ when the modifier brings the viability of the heterozygote Aa up to the level of the homozygote AA. When $\mu = S$, $F \to 1$ as $S \to 0$ and the A gene tends to complete dominance. F is large and tends to infinity only as $S/S_1 \to 1$, in which case the heterozygote Aa has the same viability as the prevailing wild-type homozygote aa and only heterozygotes carrying the modifier will be selected. Only allowing the case $\mu = S$, Haldane again excludes the possibility of evolving overdominance. If $\mu \neq S$, and is a constant, it is easily seen that $F \to \infty$ as $S \to 0$, for then the heterozygotes carrying the modifier are effectively overdominant and only such heterozygotes will be permanently maintained in the population. If, for example, $S_1 = 10$ per cent, $S = 1$ per cent and $\mu = 10$ per cent, then $F = 100$, whereas Haldane considers values of F greater than 20 most improbable. Although lack of dominance of the modifier will diminish its relative rate of increase, linkage with the advantageous gene will certainly enormously increase its advantage, more especially if the modifier is initially rare. This will also be true of modifiers tending to increase the viability of Aa when S/S_1 is nearly 1.

It seems clear, from these calculations, that an advantageous gene may evolve overdominance during the course of its evolutionary progress. Experimental evidence for this lies in the work of Levene, Pavlovsky and Dobzhansky[27]. It is also, of course, well known that if a gene is initially overdominant in the heterozygote, a balanced polymorphism will result. As pointed out by Fisher[7], this means that although overdominance as an intrinsic phenomenon may be rare, cases of overdominant genes so maintained in a population will be particularly brought to our notice. However, the evidence, as mentioned earlier in the paper, for the widespread occurrence of linkage between interacting genetic factors in association with overdominance, argues against the simplest form of overdominance associated with a genetic difference at a single site (a muton or recon in Benzer's[41] terminology). As Lewis[42] mentions, even the simplest biochemical models of heterosis in *Neurospora* and *Aspergillus* heterocaryons are the result of the complementary effect of two dominant genes.

Evidence from Micro-organisms

Even in micro-organisms with probably only limited facilities for outcrossing there is considerable evidence for the existence of linked blocks of genes controlling closely related biochemical reactions, which must have an evolutionary origin. Thus, Demerec *et al.*[43] have shown in *Salmonella* that four loci controlling sequential steps in the synthesis of tryptophan occur in a closely linked complex. Similar results have been found for loci concerned with the synthesis of histidine and proline in *Salmonella*, and also for tryptophan loci in *E. coli*[44]. That such blocks are most likely to have an evolutionary origin is emphasized by the fact that the same four steps in tryptophan synthesis, which are controlled by a linked complex in *Salmonella* and *E. coli*, are controlled by four unlinked loci in *Neurospora*[45]. Furthermore, such linked complexes are not a peculiarity of the enteric bacteria because recent work of Gross and Fein[46] has shown the existence of a linked complex in *Neurospora* concerned with the synthesis of aromatic compounds. The work of Pardee *et al.*[47] in *Escherichia coli* on the loci involved in the control of the synthesis of β-galactosidase further shows the existence of linkage between genes which are interacting at an extremely basic level. This is a situation which surely must have an evolutionary origin.

If linkage and interaction are excluded as the basic ingredients for heterosis, and as we have defined it overdominance, it is necessary to search for some intrinsic advantage of overdominance. It has been suggested by Haldane[2] that a heterozygote may be advantageous because it may give rise to more biochemical diversity than either homozygote, as occurs, for example, with the hæmoglobins. However, the occurrence of interaction products from a heterozygote[48,49] belies this simple interpretation. Moreover, the postulated mechanism of Crick and Orgel (personal communication) for heterocaryon complementation certainly suggests the possibility that some heterozygotes are likely to be intrinsically disadvantageous. Rather it seems, from the sort of survey of heterozygote viabilities carried out by Stern and Novitski[50], that a fairly wide spectrum of heterozygote viabilities is likely to occur and that there is little reason to favour any particular combination.

Conclusion

In conclusion, we would argue that overdominance as it is commonly found in outbreeding species is, at least in many cases if not all, an evolutionary phenomenon which results from the nature of an outbreeding diploid species in exposing new gene combinations in a predominantly heterozygous condition. Even in cases where overdominance is found in ostensibly inbreeding species, these almost exclusively have a previous history of outbreeding[51] during which the overdominance may have evolved in the way we have suggested. Our mechanism is just another example of the way in which the breeding system determines the genetic structure of a species, in the same way that outbreeding leads to the balanced genotype of Mather or the integrated gene pool of Dobzhansky. The root of all this organization lies in the advantage of the outbreeding system which, as Darlington[52], Mather[31], Thoday[53], and probably Darwin before them have emphasized, is its flexibility in producing new variation upon which natural selection may act. The evolutionary process is the accumulation of successively interacting genetic factors which together build up the highly

adapted and 'integrated' genotype which we now study.

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NEWS and VIEWS

Metallurgy and Fuel Technology at Cardiff: Prof. W. R. D. Jones

PROF. W. R. D. JONES will retire from the chair of metallurgy and fuel technology at the University College of South Wales and Monmouthshire, Cardiff, at the end of the present academic session. He graduated from that College in 1919, and in the same year commenced teaching duties. Coming from a family well known in mining circles, and forming a close association with the iron and steel industry in South Wales, his research work has nevertheless largely been directed towards light alloys containing magnesium. His determination of the copper–magnesium phase-diagram brought him his D.Sc. in 1932, and in the following year he was appointed head of the Department in succession to Prof. A. A. Read. Prof. Jones has always taken a very full part in academic work, being at various times deputy principal, dean of the Faculty of Science and a member of the Academic Board of the University of Wales. Combined with this he promoted a vigorous research school, the publications of which in the *Journal of the Institute of Metals* are notable contributions to our knowledge of magnesium alloys. Other work has been concerned with strain-ageing of steels and the viscosity of molten metals and alloys. His genial personality has made him popular with staff and students and he is a well-known figure in public and social life in Cardiff. He became actively interested in the South Wales Institute of Engineers and was elected president in 1953.

Dr. H. K. M. Lloyd

DR. H. K. M. LLOYD, who has been appointed to succeed Prof. W. R. D. Jones, is senior lecturer in metallurgy in the University of Nottingham. He graduated with honours in metallurgy at the University College of Swansea in 1942, and then gained industrial experience as a metallurgist in a steelworks, and afterwards became experimental officer in the Aeronautical Inspection Directorate. As a result of research on hydrogen in steel in the University of Sheffield he was awarded a Ph.D. in 1948 and the Brunton Medal, and continued for a year on the teaching staff. Since 1949 Dr. Lloyd has lectured at the University of Nottingham, first in the Mechanical Engineering Department, and from 1954 in the new Department of Metallurgy, which he largely established and equipped. He has maintained close contacts with the iron and steel industry and various engineering firms, which have sponsored some of his research work. This has chiefly been concerned with engineering metallurgy, and his work has been published in a variety of journals. In 1950 Dr. Lloyd was invited to examine metallurgical problems in an oil installation in the Persian Gulf, and during 1951 was awarded a Nuffield travelling fellowship and visited plants in the United States and Canada. His interests have extended to technical institutions and he is a governor of Corby Technical College, while as a founder member of the East Midlands Metallurgical Society he became president in 1953. In returning to Wales, Dr. Lloyd will feel quite at home in the metallurgical work which awaits him at Cardiff.

Mechanical Engineering at Sydney: Prof. P. T. Fink

AT the beginning of the current academic year, Peter Thomas Fink was appointed to the chair of mechanical engineering in the University of Sydney. Prof. Fink was educated in Birmingham, England, and the University of Sydney, where he graduated in

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aeronautical engineering in 1944. Continuing at Sydney as a research student and teaching fellow under Prof. A. V. Stephens, he worked on problems in aircraft stability in conjunction with the Commonwealth Scientific and Industrial Research Organization (Melbourne) until his appointment as assistant lecturer under Prof. A. A. (now Sir Arnold) Hall at the Department of Aeronautics, Imperial College of Science and Technology, London, in 1947. Prof. Fink spent the next ten years at the Imperial College as assistant lecturer, lecturer, and (from 1956) reader in aeronautics, playing a prominent part in the expansion of teaching and research activities under Prof. Hall and later Prof. H. B. Squire. During this period he published papers on aircraft stability and aerodynamics, including some important contributions to the understanding of the flow past slender delta wings. Prof. Fink also collaborated with Mr. Donald Campbell in the design of his record-breaking hydroplane. In 1957 he returned to Sydney to take up an appointment there as reader in aeronautical engineering.

The Iron and Steel Institute : Awards

THE Council of the Iron and Steel Institute has made the following awards: *Bessemer Gold Medal for 1961*: Mr. William Barr, director and chief metallurgist, Colvilles, Ltd., president during 1959–60 of the Institute; *Sir Robert Hadfield Medal for 1961*: Mr. Emrys Davies, managing director, Brymbo Steel Works; *Williams Prizes for 1960* (*£50 each*): Mr. T. McHugh and Mr. F. A. Kirk (Low Moor Fine Steels, Ltd.) for the paper "Some Aspect of Steel Extrusion" (*J. Iron and Steel Inst.*, **194**, 423; 1960); their co-author, Mr. R. Cox, was not eligible for an award; and Mr. J. Chapman (Steel, Peech and Tozer) and Mr. W. Montgomery (Round Oak Steel Works, Ltd.) for the paper "The Effect of Flow Distribution on Air Preheat in the Open-hearth Furnace" (*J. Iron and Steel Inst.*, **196**, 15; 1960).

A New Department for Technical Co-operation

IN the House of Commons on March 21, the Prime Minister announced new procedures for dealing with technical assistance overseas. Hitherto, requests for such assistance have been dealt with through different administrative channels, depending on whether they came from a dependent territory, an independent country of the Commonwealth or a foreign country. Such arrangements were adequate in the past, but with the growth of size and importance of plans for helping overseas countries with trained men and women, special equipment, and so on, closer co-ordination has become necessary; the Government, therefore, proposes to set up a new Department of Technical Co-operation. The new Department, Mr. Macmillan said, would be in the charge of a Minister of equivalent rank to that of a Minister of State, and while the Foreign Secretary, the Commonwealth Secretary and the Colonial Secretary would continue to be responsible for matters of general policy, within these limits the new Department would take over the present responsibility of these three overseas Departments for the provision of technical assistance other than capital projects. It would be concerned with much of the technical assistance provided with the help of the United Kingdom through international organizations as well as with that given direct to the recipient countries. As one of its duties the new Department would administer the scheme set out in the White Paper of last October for the continued employment of overseas offices; but the transfer, promotion and discipline of the Overseas Service in dependent territories would remain the responsibility of the Colonial Secretary.

The statement was warmly welcomed by Mr. H. Gaitskell for the Opposition, and in reply to questions Mr. Macmillan added that the Vote would be separate and the Minister would be a member of the House of Commons. Capital aid would remain with the three overseas Departments, and the existing Colonial organization would continue. Educational assistance through the United Nations Educational, Scientific and Cultural Organization would still be a matter for the Ministry of Education, and the work of the British Council in providing teachers of English would continue, though Mr. Macmillan agreed that all this would need co-ordination, and that the new Department would take over many requests for educational assistance. It might also be preferable to continue to operate in inter-university matters through existing non-governmental bodies such as the Inter-University Council for Higher Education Overseas, or the Council for Overseas Colleges of Arts, Science and Technology and the Association of Universities of the British Commonwealth, although he thought the new Department might be able to help here, too. In reply to a suggestion that the new Department might have specific responsibility for the Inter-University Council, Mr. Macmillan said he would not like to give a precise answer without consulting the Chancellors of the Universities. Mr. Macmillan said, reasonably enough, that it would take some time to work out all the details. The new Minister would be concerned with providing training facilities in Britain for men and women from these territories, particularly from within the Commonwealth, as well as with finding and sending abroad technically trained people of British nationality. Some would belong to the Overseas Services, and others would be serving on contract for a limited period. A similar statement, made simultaneously by Lord Hailsham in the House of Lords, added that the proposals would mean bringing together work done in overseas Departments, and that in general the staff would come from these Departments. He also made it clear that the new Department would not be responsible for the Colonial Development Corporation, relations with which would continue to be handled through the Colonial Office and the Commonwealth Relations Office. The necessary Bill was read for the first time in the House of Commons on March 23.

The American Institute of Biological Sciences

SUPPORTED by a grant from the National Science Foundation, the American Institute of Biological Sciences has undertaken a Biological Sciences Communication Project to seek ways of improving the overall effectiveness of the control and dissemination of biological information. An examination of the methods of acquiring, indexing, storing and retrieving printed scientific literature will be followed by an investigation into the needs for and use of information by biologists, and of the characteristics of the dissemination activities of existing agencies. The effectiveness of visiting biologist's programmes, conferences and symposia will also be appraised and the project will consider developing a practical method for obtaining and disseminating in the

United States valuable research information obtained by United States scientists in visiting other countries. The project will also take account of the problem of scientific communication as influenced by the training of scientists and of the needs of teachers, administrators and science writers, which may be quite different from those of the research worker. An advisory committee has been formed to assist the Institute in providing liaison among allied biological groups.

Funds for Industrial Research in the United States

A PRELIMINARY report issued by the National Science Foundation indicates that funds for research and development by industry in the United States amounted in 1959 to 9,400 million dollars, an increase of 15 per cent on 1958, and the total is expected to reach 10,000 million dollars in 1960 (*Reviews of Data on Research and Development*, No. 24. N.S.F. 60-61. Washington 25, D.C., December 1960). Of the total, 5,400 million dollars came from federal funds, an increase of 17 per cent, whereas that financed by industry itself increased by 12 per cent. Expenditure on fundamental research was 344 million dollars, an increase of 17 per cent on 1958. Three-quarters of the Federal contribution went to two industries heavily engaged in research and development projects concerned with missiles, rockets and satellites, the aircraft industry alone receiving 2,500 million dollars, and the other industry, electrical equipment and communication, 1,600 million dollars.

Computing Chemical Plant Automation

THE first British-produced digital computing system to be used to control a chemical process without human intervention has been ordered by Imperial Chemical Industries, Ltd., for use in their chemical plant at Fleetwood, Lancs. The machine concerned is the Ferranti *Argus* computer, which, because it uses only solid-state electronic elements, is deemed reliable enough to operate in relatively 'docile' chemical processes without a constant human monitor. It is interesting to note that the computer is of the pluggable sequence type; the 'plugs' in this case being small ferrite rods which alter the coupling between mesh points of a set of mutually orthogonal conductors. In line with recent thought, the *Argus* has facilities for time sharing, the acceptance and emission of analogue signals, and the capacity of accepting additional drum storage of up to 50,000 words. The Imperial Chemical Industries, Ltd., installation has the basic capacity of 1,024 orders and core storage for 1,024 words. More than 300 analogue signals of six different types can be read in and outputs to control 100 pneumatic valves are provided. The arithmetical speeds are such that 50,000 additions or 10,000 multiplications can be performed each second.

Coal Research in Australia

THE Coal Research Division of the Commonwealth Scientific and Industrial Research Organization has during the past four years published an attractive series of 16-page pamphlets (*Coal Research in C.S.I.R.O.*, Nos. 1 (May 1957)–11 (August 1960). Melbourne: Commonwealth Scientific and Industrial Research Organization) at the rate of three a year, describing facets of its work. Presentation and style are excellent; the articles are brief, popularly written and broadly informative, yet technically precise. Directed towards industrial producers and users of coal, the series would appear to serve four purposes and these may be illustrated with reference to recent articles. The 'educative' function is represented at present by a series on maceral, petrological constituents of coals roughly analogous to the minerals in rocks. Their nature and appearance and their influence on properties of coal are described with the aid of typical photomicrographs. Descriptions of 'techniques' and of 'recent research work' are closely related to one another, though the emphasis differs greatly between general application and specific results according to the topic under discussion. Examples of the former are "Fluidization Technique", "Porosity Measurements", and fundamental methods of investigation such as "Molecular Still for Tar Distillation" and "High Sensitivity Gas Chromatography". Among the latter may be mentioned "Coal Structural Studies", "Coal Macerals in Solution", "Char Blending makes Better Coke" and "Air-Flow in Cupolas"; the aim, methods used, type of information obtained, and likely applications or significance are all touched on. Finally, some articles might be regarded first and foremost as 'surveys of a field', as "Coke Production and Cupola Practice", "Utilization of High-Ash and Small Coals" and "Pitch for Making Electrode Carbon". The last-mentioned article, for example, gives information on methods of preparation and properties required. Each issue concludes with abstracts of papers published by staff of the Coal Research Division. While the breadth of treatment assists understanding and is to be preferred to a parochial approach, the impression is sometimes created (since acknowledgment of work elsewhere is not made) that the techniques, methods of interpretation, and detailed findings alike originated in the Research Organization's laboratories. Sometimes this is so; but often the work described forms part of the world-wide advance, and the article is partly concerned with this broader advance. These pamphlets deserve attention and success for their competent attempt to 'sell' research in industry.

Technological Development in Poland

A RECENT issue of the *Review of the Polish Academy of Sciences* (No. 2, 5, April–June 1960) contains a survey by I. Malecki of fifteen years of technology in Poland and one by T. Nowicki of the six-years work of the Polish Academy of Sciences' Institute of Basic Technical Problems founded in 1953. Dealing first with the starting up of technology in Poland after the War, and the reconstruction and development of its technical basis, Dr. Malecki describes the development of particular industries, including transport and communications. Power production increased by 310 per cent between 1946 and 1958, production of cast iron and steel from 1,200,000 tons and 1,900,000 tons, respectively, in 1948, to 3,900,000 tons and 5,600,000 tons in 1958. There were major advances in the engineering industry which represented 19 per cent of industrial production in 1958 compared with 13 per cent in 1938, and the output of the chemical industry rose nine-fold compared with 1938. The industry now provides 70 per cent of pharmaceuticals compared with 12·5 per cent in 1949. The Institute of Basic Technical Problems comprises eight scientific centres covering three main fields: electrotechnics, mechanics and technical physics, and includes departments for the theory of

telecommunication, electrical engineering, electronics, mechanics of continuous media, fluid mechanics, vibrations research and analogues, and a laboratory for research on isotopes.

Radioisotopes and Radiation in Entomology

THE International Atomic Energy Agency in Vienna recently convened a symposium under the above title with the object of discussing and developing plans for the wider use of radioisotopes and radiation in the control of insect pests. It was held in Bombay during December 5–9, 1960, when twenty-five papers were read and discussed by delegates from the host country, India, Federal Republic of Germany, France, Italy, Pakistan, Philippines, United Kingdom, United States and U.S.S.R. The papers covered a pertinent range of topics, such as the use of irradiation as a direct means of disinfesting food products, as an indirect means by inducing sterility in male insects, and so interrupting reproduction in field populations, and the use of radioactive tracers in entomological and insect biochemical research. There was lively but constructive discussion, for example, in the respective merits of static radioactive materials and electrical machines as radiation sources. Through the kindness of the Indian Government the delegates visited the Atomic Energy Establishment and the new reactor at Trombay, where impressive facilities have been created for the peaceful applications of atomic energy. There are major agricultural and insect pest problems in the less-developed regions of the world in which irradiation and radioisotope techniques can undoubtedly play a valuable part. Excellent facilities for the application of these techniques now exist in India, so that the symposium was indeed timely and effective. The balanced and up-to-date nature of the programme will render the collected proceedings a valuable document provided that publication is not long delayed.

Sabouraudia

THE aptly named *Sabouraudia*, the new journal of the recently formed International Society for Human and Animal Mycology and the first number of which was published during January, can truly be regarded as a milestone marking the rapid extension of the science of mycology into the sphere of human and animal mycoses (Vol. 1, Part 1. Edited by J. C. Gentles. Pp. 72 + 12 plates. (Edinburgh and London: E. and S. Livingstone, Ltd., 1961). Subscription price per volume (four issues) 80*s*. or 12 dollars. Single parts 20*s*. or 3 dollars). Indeed, as pointed out in an excellent review of the subject by the president, Dr. Juan Makinnon, order is steadily being brought out of chaos by the insistence of a few discerning enthusiasts on the observance of the rules of the international codes of nomenclature for bacteriology and botany. It is, perhaps, the recent trend towards accuracy in species diagnosis and nomenclature of the causal fungi, in contrast to the over-emphasis on clinical aspects characteristic of older work, which has been responsible for the enhanced status of medical and veterinary mycology. This is well exemplified by two papers describing some of the techniques being evolved for obtaining the sexual, or 'perfect', states of parasites content to be known previously only by their conidial states. The remaining six papers are of an agreeably high standard, and mycology will be well served if the journal continues to maintain this standard. It is printed clearly on good quality, quarto-sized paper with excellently produced illustrations, and includes book and film reviews and news of scientific societies in a total of 71 pages.

Protection of Cleaned Iron Objects

THE protection of iron objects after they have been cleaned has for a long time been a major problem in the conservation of museum objects. In the February issue of the *Museums Journal*, Mr. K. J. Barton details some experiments and conclusions on this subject. The most interesting result is that the phosphate coated object (using one of the commercial phosphoric acid cleaners) shows no evidence of corrosion under the experiments. The one disadvantage of this coating is that the resultant colour is poor and always patchy. This can be overcome by dyeing the phosphate coating black with 'Hematine' crystals, thus giving a matt surface which can be polished with a stiff brush. Other tests covered vapour-phase inhibitors using cyclohexylamine carbonate. Shell Nos. 220 and 260 were found to be the most effective and their use is limited to objects made of steel, iron, tinplate, zinc and aluminium. They must not be used in association with lead or copper since they are liable to attack.

Atmosphere Temperature Fluctuations

THE subject of climatic change is one which has for long interested climatologists and meteorologists, but especially so during recent years. Direct temperature observations, the recession of glaciers, the movement of fish and insects northwards in the northern hemisphere, as well as a similar movement of the tree-line have all indicated an appreciable rise in atmospheric temperature in many parts of the world during the past few decades. A recent contribution to the subject has been made by G. S. Callendar, of the Ministry of Aviation, in a paper which appears in the *Quarterly Journal of the Royal Meteorological Society* (87, No. 371; Jan. 1961). From his analysis he concludes that the rising trend is significant from the Arctic to about 45° S. lat., but is small and indeed locally non-apparent in regions below 35° N. as yet. A number of theories to account for the rise have been advanced, and there has been much speculation as to whether or for how long it will continue. One widely held theory is to the effect that the rising trend is a result of increased incoming solar radiation, due either to an increased output of solar energy or to an increased atmospheric transparency resulting from a decrease in volcanic activity. Callendar considers that such a hypothesis is not inconsistent with the observed zonal short-period fluctuations, but that it fails to explain the pattern of the overall climatic trend. The latter is considered to be not incompatible with the increased carbon dioxide theory, which is to the effect that the trend could be due to back radiation from the additional carbon-dioxide produced by fossil-fuel combustion. The points at issue seem to be: Does Nature control the whole process, or has human activity caused the trend, on which Nature has merely imposed the fluctuations?

Corrosion Prevention

A SPECIAL exhibition on metallic corrosion and its prevention is being organized at the Science Museum, South Kensington, during March 27–April 22. This collection of exhibits has been

assembled by the Corrosion Group of the Society of Chemical Industry to mark the first International Congress on Metallic Corrosion, to be held in London during April 10–14. It has been estimated that the yearly cost of corrosion to Great Britain alone is at least £200 million (£5 a head per annum); the subject is, therefore, of great national economic importance and of direct interest to the layman. For this reason although the exhibition will be of particular interest to the delegates to the Congress, it has been designed so as to be intelligible and interesting to the non-specialists who form the majority of visitors to the Museum. It sets out to answer in simple terms the questions: What is Corrosion? How and when does it take place? What can be done to prevent it?

University Entrance

A second edition of *University Entrance—The Basic Facts* has appeared. It will enable one to find out (*a*) which universities provide first-degree courses and in what subjects; (*b*) the minimum to be attained in matriculation for entering individual universities; (*c*) faculty and departmental requirements; (*d*) the approximate cost of study based on amounts paid at present by the Ministry of Education to scholars who need maximum help; (*e*) what the present policy is regarding grants to students; the approximate scale of awards and parental contribution. It is suggested to readers that they watch the national or educational Press for announcements about the Government's future policy on financial help to students. The pamphlet, published by the National Union of Teachers, can be obtained from Hamilton House, Mabledon Place, London, W.C.1 (price 4*s.* 6*d.* post free). It should be of great help to head-masters, teachers, parents and students.

Friedrich Vieweg and Son Anniversary Competition

On April 1, 1786, Friedrich Vieweg established at Brunswick a publishing house that was to become associated with such great names as Goethe, Herder, Alexander and Wilhelm von Humboldt, Justus von Liebig, Gottfried Keller, Wilhelm Raabe, Hermann von Helmholtz, Wilhelm von Bode, Madame Curie, Arnold Sommerfeld, Ludwig Prandtl, Albert Einstein, Max von Laue and Erwin Schrödinger. During the past years the house has been mainly concerned with the publication of books and periodicals in the fields of mathematics, natural sciences and engineering. On the occasion of its one hundred and seventy-fifth anniversary the house of Friedrich Vieweg is offering a number of prizes for papers in the field of mathematics, physics and chemistry for publication in book form, to be judged by a panel of distinguished scientists. Further information can be obtained from Friedrich Vieweg und Sohn, Postfach 185, Burgplatz 1, Braunschweig, Germany.

Announcements

Dr. J. T. Delacour, formerly director of the Los Angeles County Museum and president emeritus of the International Council for Bird Preservation, has been awarded the Addison Emery Verrill Medal of the Peabody Museum, Yale University.

Dr. A. R. Battersby, lecturer in chemistry in the University of Bristol, has been awarded the Corday-Morgan Medal and Prize of the Chemical Society, in consideration of his work on the stereochemistry of emetine and its congeners, and also on the chemistry of curare alkaloids and the biogenesis of papaverine. The award consists of a silver medal and a monetary prize.

The British Iron and Steel Research Association will hold open days at its Sheffield Laboratories on June 15 and 16. Further information is available from the Association, 11 Park Lane, London, W.1.

The spring meeting of the Parasitology Group of the Institute of Biology is to be held at Wills Hall, Bristol, during April 11–13. Included in the programme will be an invited address by Prof. C. P. Read on "The Host-Parasite Interface: Molecular Basis of Parasitism". Further information can be obtained from Dr. L. P. Joyner, Central Veterinary Laboratory, Ministry of Agriculture, Fisheries and Food, New Haw, Weybridge, Surrey.

A postgraduate course in nuclear technology (chemical) is being administered by the Department of Chemical Engineering and Chemical Technology, Imperial College of Science and Technology, London. The course is to be full-time and of one year's duration. Applications for admission should be made by June 1 to the Registrar, Imperial College of Science and Technology, London, S.W.7, from whom further information and application forms can be obtained.

Two lectures on "Recent Advances in the Radiation Chemistry of Aqueous Systems" will be given by Prof. Gabriel Stein of the Department of Physical Chemistry, Hebrew University of Jerusalem, at the Imperial College of Science and Technology, London, during May 3–10. The first lecture will be on basic processes in aqueous solutions and the second on some systems of biochemical interest. Further information can be obtained from Dr. A. J. Swallow, Department of Chemical Engineering and Chemical Technology, Prince Consort Road, London, S.W.7.

The European Association for Research on Plant Breeding is holding a conference on "Environmental Factors in the Distribution of Fruit Varieties" at Het Huis de Provincie, Arnhem, during April 27–28. The programme will include two sessions, namely: (1) surveying work on local growth conditions and plant responses; (2) analysis of causal relations. Further information can be obtained from the Institute of Horticultural Plant Breeding, P.O. Box 16, Wageningen, The Netherlands.

The British Leather Manufacturers' Research Association is holding open days at its Laboratories, Milton Park, Egham, Surrey, during May 2–4. Included in the programme are two lectures, one by Mr. H. Bradley, director of research, British Boot, Shoe and Allied Trades Research Association, on "Requirements of the Shoe Industry from the Leather Industry", and the other by Dr. K. W. Pepper, director of the British Leather Manufacturers' Research Association, on "Adhesion in the Manufacture of Leather and Leather Goods". Further information can be obtained from the director at the Laboratories.

Erratum. In *Nature* of March 18, p. 865, column 2, line 16, for 'Melville' read 'Metcalfe'.

THE PRESENT STATE OF ERGODIC THEORY*

By Dr. I. E. FARQUHAR

Queen Mary College, London

THE purpose of ergodic theory is to establish the necessary and sufficient conditions for a system to approach equilibrium from a non-equilibrium situation. It does not define the manner in which a system approaches equilibrium: that is the province of transport theory and master equations. Ergodic theory has, in fact, the characteristics of a mathematical existence theorem, and it possesses, accordingly, both the strength and the weakness of such a theorem. Its strength lies in its generality—it deals with arbitrary physical systems in arbitrary situations. Its weakness appears whenever attempts are made to apply it to any specific physical situation.

The procedure is to derive conditions for the equality of time and ensemble averages, in classical statistics, of phase functions, and in quantum statistics of expectation values of operators. Here there is illustrated one example of the lack of specific application of ergodic theory, for the time averages considered are always evaluated over an infinite period. To interpret these time averages physically, that is, as values observable physically during the time intervals occupied by measurements on the system, it is necessary to assume that the appropriate relaxation time of the system is much shorter than the duration of the measurement. Yet ergodic theory in itself provides no estimate of this relaxation time, so that, to apply ergodic theory in any specific case, recourse must be had either to some other theory, or to experiment, in order to obtain this relaxation time. Further, just as it says nothing about values of relaxation times, so ergodic theory yields no information regarding values of transport coefficients, although it is perfectly consistent with the occurrence of transport processes.

In classical statistics, Birkhoff's theorem[1] remains basic. It asserts the equality of time and ensemble averages almost everywhere on the surface of constant energy in phase space corresponding to the energy of an isolated system, provided this energy surface is metrically indecomposable. This is equivalent to the requirement that there are no invariant integrals of the motion independent of the energy. It has, in fact, been shown[2] that time and ensemble averages are equal, almost everywhere on the reduced manifold in phase space which is defined by the set of *all* invariants of motion of the system.

Although metrical indecomposability is thus a criterion for ergodicity, the trouble is that it is not known how many invariants of the motion an arbitrary physical system possesses. Hence, efforts have been made to circumvent the question of metrical indecomposability by restricting the scope of the theorems.

One method of doing so is to give full weight to the fact that statistical mechanics deals with macroscopic systems. Birkhoff's theorem is a result of general dynamics, independent of the number of degrees of freedom of the system. But it may be inquired whether time and ensemble averages are equal asymptotically in the limit as the number of degrees of freedom of the system becomes infinite. An asymptotic ergodic theorem of this form, without any requirement of metrical indecomposability, has been given by Khinchin[3] by restricting the class of phase functions, the ergodic behaviour of which is required. Khinchin's restriction is to the class of phase functions the phase dispersion of which is small, although it is only for phase functions which are sums of corresponding functions for the individual molecules of a system with separable Hamiltonian that Khinchin has shown the phase dispersion to be small. In certain cases where Birkhoff's theorem asserts that a system is non-ergodic, Khinchin's approach gives the positive result that the departure from ergodic behaviour is, nevertheless, vanishingly small in the limit of an infinite number of degrees of freedom.

In all these cases, the theorems are valid 'almost everywhere', and so some form of 'coarse-graining', by introducing phase cells, is required to avoid effects associated with exceptional phase points from showing up in practice.

In quantum statistics the basic treatment has been that of von Neumann[4], who showed how phase cells and 'coarse-grained' operators may be defined, which are consistent with the quantum-mechanical commutation rules. It is in terms of such coarse-grained operators and corresponding coarse-grained distributions that thermodynamical properties are described. By making use of the macroscopic nature of the system, here reflected in the high density of quantum energy-levels, von Neumann established an ergodic theorem, but only at the expense of introducing an averaging over all possible coarse distributions; these are treated as equally probable. Without such an averaging, von Neumann could not eliminate reference to the particular coarse-grained distribution used. Von Neumann's proof depended on the Hamiltonian of the system being non-degenerate and this requirement of non-degeneracy came to be regarded as the quantum-mechanical ergodicity condition, analogous to the classical criterion of metrical indecomposability.

However, it was shown recently[5] that von Neumann's argument does not in fact yield any criterion for ergodicity, since his proof may be carried through even if the Hamiltonian is degenerate. It is the assumption in von Neumann's approach, of equal *a priori* probabilities for coarse distributions, that leads to the result that *all* systems are ergodic. This overstrong assumption removes not only the possibility of obtaining ergodicity conditions[6], but also any requirement on the time evolution of the system other than that the norm of the state vector be constant. In particular, the time evolution operator need not be unitary[6]. The assumption of equi-probability of coarse distributions

* Substance of paper at a conference on "Statistical Mechanics and Irreversibility" arranged by the Institute of Physics and the Physical Society and held at Queen Mary College, London, during December 19–20.

thus leads to results which are too general to be of physical significance. This does not, of course, invalidate von Neumann's general method of averaging over coarse distributions, but only the special case in which the *a priori* distribution of these coarse distributions is assumed equi-probable.

An alternative proposal put forward in a series of recent papers by an Italian school[7] is to average, not over all coarse distributions for a fixed initial state, but over all initial states for a fixed coarse distribution. It is assumed that all initial states are *a priori* equally probable and hence the averaging methods developed by von Neumann may be used. Once again, this treatment is too general to yield any ergodicity criterion; but, unlike von Neumann's method, it does require that the time evolution operator of the system be unitary.

To obtain ergodicity conditions it would be necessary, in both von Neumann's and the Italians' treatments, to make a less strong assumption regarding the *a priori* distribution, whether of coarse distributions or of initial states. The Italians themselves[8] have gone some way towards relaxing this strong assumption by replacing the averaging over all initial states of the entire energy shell by separate averaging within each phase cell: the initial states within any phase cell again are assumed equally probable. This procedure does yield ergodicity conditions, but the conditions are somewhat formal and, although they can be linked with the Hamiltonian of the system, the connexion has not been worked out fully. Furthermore, as with the classical criterion of metrical indecomposability, it would appear difficult to determine whether actual physical systems satisfy the conditions. Other ergodicity conditions, which again have a rather tenuous connexion with the Hamiltonian, have been obtained by Landsberg[9], who considers a class of averaging processes which includes, as special cases, averaging over coarse distributions and over initial states. The class is defined in such a way that averages are independent of particular phase cells and quantum states, and, as with Khinchin's theorem, a condition on the averaging procedure is required.

Ergodic theory has been attacked[10] on the grounds that it is not of physical significance to consider, as it does, an isolated system. Two points may be made here: first, in the attempt to relate dynamical and thermodynamical properties of a system, ergodic theory provides only a first step; once ergodic behaviour has been established, the system of interest, hitherto considered isolated, must be coupled to a large heat-bath, and only the combined system is then regarded as isolated. The interaction between system and surroundings is vital. Secondly, those who favour introducing irreversibility[10] by way of external influences at the boundaries of a non-isolated system do not appear to be justified in assuming arbitrarily that these external influences are random. Although an arbitrary assumption regarding *a priori* probabilities appears both in von Neumann's and in the Italians' treatments, this assumption refers to methods of handling the system rather than to the system itself. The assumptions therefore are not 'assumptions of disorder', in the sense in which the term was used in early work on kinetic theory.

The work of van Hove[11] on master equations does not fall within the province of ergodic theory, since it deals with particular systems and seeks to study in detail their time-development. It seems, however, that a generalization of this approach may well prove to be a most fruitful method of studying the approach to equilibrium of arbitrary systems.

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TERPENE CHEMISTRY

A SYMPOSIUM on terpene chemistry, organized by the Chemical Society, was held in the Chemistry Department of the Imperial College of Science and Technology on February 23, and attracted an audience of more than two hundred. The programme consisted of six main lectures.

The first session was opened by the president, Sir Alexander Todd, who gave a warm welcome to the speakers and visitors from abroad. Prof. E. R. H. Jones was chairman of the opening session, in which the first paper on "Terpene Compounds with Ten-membered Rings" was given by Prof. F. Šorm, of Prague. After a brief historical introduction, the chemistry of germacrome, a typical ten-membered cyclic terpene, was reviewed in detail, special reference being made to the trans-annular reactions which are so characteristic of this series. A theoretical treatment of the non-classical interaction of double bonds in this series was also provided. Further examples of structural determinations of this class of terpenes were provided by costunolide, balchanolide and *iso*balchanolide, cnicin, scabiolide and parthenolide.

Later, Prof. B. C. L. Weedon (Queen Mary College) reviewed his recent work on structure determination and synthesis of carotenoids and their biological precursors. Particularly striking results have been achieved with the aid of nuclear magnetic measurements carried out and interpreted by Dr. L. M. Jackman at the Imperial College. Examples included spirilloxanthin, spheroidene and the paprika ketones capsorubin, capsanthin and capsanthone. Physical methods have also been applied successfully in determining the structures of a variety of hydrolycopenes, for example, phytoene, ζ-carotene and neurosporene, believed to be biogenetic intermediates of carotenoids. New methods for building up the carotenoid ring systems were also described as part of the syntheses of canthaxanthin and astacene.

After lunch, Prof. D. H. R. Barton introduced Prof. O. Jeger (Zurich), who discussed the structures of a series of oxidation products of the diterpenes manool and sclareol. Many of these had potential values in the perfumery industry, and evidence for the structures suggested was based on numerous physical measurements as well as chemical degradations and correlations with other diterpene degradation products; a notable feature of this symposium was the extensive use which chemists are making of nuclear magnetic resonance measurements in structural problems. Prof. H. C. H. Erdtman (Stockholm) then correlated, so far as was possible, the distribution of terpenes among the various orders of the Coniferae and stressed the taxonomic importance of this group of organic compounds. This extensive survey will have far-reaching effects on biogenetic studies of the terpenes; in the course of the work several new terpenes were discovered and the elucidation of these structures was also described.

In the final session, the two papers presented related to the determination of the structure of the complex terpenoid bitter principle, clerodin. Prof. Johnson, as chairman, introduced Prof. Monteath Robertson, who described the potentialities of the X-ray diffraction method in the elucidation of structures of molecules containing up to one hundred atoms (other than hydrogen).

Prof. Robertson's colleague, Dr. G. A. Sim, then illustrated the general points by discussing the case of clerodin (as a simple derivative) in detail. This elegant work was only one of several similar topics solved by this method in the Glasgow laboratories. Prof. Barton, in his usual lucid style, then discussed the underlying chemistry of this substance and showed how the structure had been derived on the basis of chemical degradations. His work was also complementary to the nuclear magnetic resonance measurements carried out by Dr. Jackman, who described this aspect of the problem. In the ensuing discussion, Dr. K. H. Overton (Glasgow) outlined his elucidation of the stereochemistry of the bitter principle, columbin.

A. W. Johnson

AUSTRALIAN ARID ZONE TECHNICAL CONFERENCE

AN Arid Zone Technical Conference was held at Warburton, Victoria, during December 5–9. It was attended by more than seventy delegates representing a very wide range of organizations and sciences. Several overseas visitors were present as observers, including Dr. P. C. Raheja and Dr. Y. Satyanarayan (Central Arid Zone Research Institute, India), Dr. M. H. Aslan (Desert Range Research Station, Egypt) and Mr. M. U. Khan (Meteorological Service, Pakistan).

The programme was organized into nine major sessions. In Session 1, the physical characteristics of the Australian arid zone were outlined in terms of geology (L. C. Noakes, Bureau of Mineral Resources, Canberra), geomorphology (J. A. Mabbutt, Commonwealth Scientific and Industrial Research Organization (C.S.I.R.O.), Canberra), soils (C. G. Stephens, C.S.I.R.O., Adelaide), vegetation (N. C. W. Beadle, University of New England, Armidale), and climate (H. L. Ashton, Bureau of Meteorology, Melbourne). This material was primarily descriptive in nature and provided a continent-wide background for those scientists not directly active in arid zone problems, or concerned with only one geographical locality in the arid zone.

Sessions 2 and 3 were devoted to the principles and problems of plant and animal production and husbandry, and formed the central basis of the conference. Review papers were presented on plant production (R. O. Slatyer, C.S.I.R.O., Canberra), and utilization (R. M. Moore, C.S.I.R.O., Canberra), and on animal production (W. V. Macfarlane, Australian National University, Canberra), and animal husbandry (G. R. Moule, C.S.I.R.O., Prospect and J. H. Whittem, Animal Industry Branch, Alice Springs) and an additional thirty-four contributed papers covered a wide range of specific subjects within these fields of research. In Session 2 data were presented indicating that the existing communities are relatively inefficient in the conversion of rainfall to plant material, and that this phenomenon is due in part to extreme soil mineral deficiency and the physiological and ecological characteristics of the individual species, as well as to the low and intermittent rainfall regime. Experimental data were also presented on the possibilities of introducing new plant species and the problems associated with their establishment, persistence and natural dissemination. This information, together with a recognition of the desirability of concentrating water run-off for more effective use, led to the general concept of concentrating effort for increased plant production on the most favoured parts of the landscape, rather than attempting a blanket improvement of the whole countryside.

The management of the pasture communities under grazing is of special importance under arid conditions, partly because of the need to maintain reserves of perennial evergreen species for drought reserve and partly because of the delicate plant-climate balance and the ease with which communities can be damaged by overgrazing. Also, efficient utilization is influenced by property development, particularly by spacing of watering points and fencing. It was considered that the most advantageous developments in this field can only be achieved if the requirements and responses of the animal are also considered. In consequence, integrated studies of both plants and animals, with the development of range condition standards and management procedures, was recommended.

The main form of commercial production in arid areas in Australia appears likely to remain some form of animal production and this will be restricted mainly to sheep and cattle. In Session 3, it was emphasized that there is need for more information about both species, but particularly cattle, and with special reference to adaptation, nutrition and reproduction in the more tropical parts of the zone, where there is at present active development of the cattle industry.

As any widespread change in the level of nutrition in the more arid areas will probably be a slow process, emphasis was placed on the need to breed better adapted and better producing animals, either by selection within the genetic material already in the country or by introducing new genes. Evidence was

given of advances in the first field, and it was also indicated that the determination of selection criteria could be assisted by more basic physiological study, one particular example being potassium-levels in the blood.

To a large extent, the cattle population of the arid area and to a lesser extent the sheep population, exist as a series of wild herds and flocks. While property management aims at bringing them under better control, management practices are introduced against a background of almost complete lack of quantitative information on the ecology of the herds and flocks, their drinking and grazing habits, reproductive patterns, the nature and time of mortalities, and their individual, group and herd behaviour. It was recommended that a detailed study of these, using ecological and behavioural approaches developed by wild-life ecologists, should be encouraged.

Sessions 4–7 dealt with aspects of water and included a review paper (R. Powles, Soil Conservation Service, Condobolin) and contributed papers on soil and water conservation, underground water, irrigation and special aspects such as the suppression of evaporation from water storages, the sealing of earth dams, demineralization, and the significance of advection phenomena in arid zone irrigation areas. The importance of evaluating quantitatively the distribution and nature of occurrence of the limited water resources was emphasized. For maximum effectiveness it was suggested that such an inventory should reveal the dynamic characteristics of individual aquifers and catchments, and since it is impossible, at present, to envisage the appraisal of all water resources in this manner, it was proposed that a systematic approach should be adopted in which selected type situations within defined landscape patterns (land systems) could be studied and the results extrapolated as widely as possible.

Session 8 dealt with human settlement in arid regions and included contributions on demography (W. D. Borrie, Australian National University, Canberra), human function (W. V. Macfarlane, Australian National University, Canberra) and human organization (R. K. Macpherson, University of Sydney) in the Australian arid zone. It was apparent that there is a tendency in Australia to take arid zone environments for granted with all their physical disabilities and other stresses on human beings. The conference stressed that much could be done to make living conditions more acceptable.

The conference was impressed by the advantages following from the combined discussion of arid problems by the representatives of many different disciplines and stressed the need to define, in biological terms, the problems of plant and animal production specific to the arid zone ecosystem. Perhaps the main impression gained was a general confidence among delegates that research would achieve more efficient production from arid and semi-arid areas. There was much evidence of research having entered a phase in which quantitative data were becoming available to replace subjective estimates. This particularly applied in such fields as mineral resources, hydrology, microclimatology, geomorphology, plant and animal physiology, animal breeding, economics and human physiology.

C. S. Christian
R. O. Slatyer

FUTURE OF NATURAL FAUNAS

THE twenty-sixth annual meeting of the Association of British Zoologists was held at the Zoological Society of London on January 7 under the presidency of Prof. C. M. Yonge. The theme of "Looking Ahead—The Future of Natural Faunas" was introduced by Sir Julian Huxley, who described and illustrated, by means of colour slides, what he had seen on his recent visit to East Africa. The central problem there, he said, was essentially one of human ecology. The fauna was a relic of the pre-human ecological climax and still presented a unique array of types in which some twenty-five or more species appeared to be collaborating in exploiting a number of exceptionally brittle habitats. The advent of pastoralism had brought many problems in its train and the situation was aggravated by the African, who thought of cattle as a symbol of wealth and prestige rather than as a source of protein. Recent studies by a number of investigators, including Fulbright Scholars, had shown that the land could be induced to yield more protein per acre from game than from cattle. In South Africa, a depleted fauna was being given some encouragement in game 'farms' from which there was a large demand for animals for re-stocking purposes. Sir Julian emphasized the importance of the tourist trade as an economic factor of conservation and he pointed out that parks were already being recognized as a source of tribal pride. The future of the fauna of East Africa was certainly in the balance, but the situation was not nearly as bad as he thought it would be when he went out there. Sir Julian concluded by directing attention to the conference at Arusha in Tanganyika in September, which was being organized by the International Union for the Conservation of Nature and other agencies with the object of influencing African public opinion towards conservation and the wise use of natural resources, including wild life.

Mr. Max Nicholson (director-general, Nature Conservancy) said that apart from the virtually unpredictable effects of human population pressure during the next forty years, the future of the British fauna depended to a great extent on climatic changes. These might include some brought about by the agency of man such as a barrage across the Bering Strait, the break up of Arctic pack-ice by atomic means, the reversal of flow of some of the big Russian rivers and the flooding of depressions in the Sahara. The consequent rise in ocean-levels and the effects on the course of the Gulf Stream might well induce a Mediterranean type of climate in Britain. Birds could be regarded as sensitive indicators of climatic change, and it was significant that the rook and green woodpecker were steadily moving north. Although it was possible that no species would be lost in the next forty years, there was a tendency towards the replacement of a broad range of specialized species by a narrow range of adaptable species. Among the outstanding hazards to which the fauna was subject were the exploitation of waterways, marshland and estuaries, pollution by oil and toxic

chemicals, mortality on fast highways, the burning of heathland and the sprawling out of cities. Isolation was becoming increasingly difficult to find and the time might well be coming when it would have to be administratively regulated. Referring to the work of conservancy in managing and studying what he hoped would eventually be some 150 reserves in Britain, a number representing the full spectrum of the country's natural habitats, Mr. Nicholson said that people were getting away from the sentimental idea that reserves were places where nothing was killed. The cropping of vertebrate resources might prove to be the best form of land management.

Dr. L. Harrison Matthews (scientific director of the Zoological Society of London) said that of the three orders of marine mammals, the Cetacea, the Pinnipedia and the Sirenia, the future of the whales was unquestionably precarious, but as the future of whaling was precarious too, the two facts might cancel each other out. There had been a virtual break-down in the international control of the situation; populations of the blue whale might be at a minimum for recovery and the overall length of the fin-whale was getting smaller. However, with the advent of pelagic factory-ships, whaling as an economic proposition might stop long before the whales were killed off, although the Japanese, who hunted for meat, might well go on. He thought that if carefully managed the future of the seals was reasonably secure: the elephant seal was now re-colonizing its former haunts in the Antarctic and the walrus seemed to be holding its own. Less, however, could be said about the future of the sirenids, the dugongs and manatees. The latter were now less common than they were in the Caribbean, but were reasonably plentiful in northern South America. Recent trials had shown that the manatee had an unusual appetite for grasses and aquatic herbs, and if it could be successfully introduced into weed-choked waterways it might become a useful and important animal in the ecology of the tropics.

Mr. P. H. Greenwood (British Museum (Natural History)) said that the freshwater fauna of tropical Africa, particularly the fishes, posed numerous evolutionary, zoogeographical and ecological problems. Each lake was characterized by a high degree of endemism, especially among the Cichlidae, which had undergone extensive adaptive radiation in the past ten million years. Likewise, each river system was characterized by its own assemblage of species co-existing with others of a more general distribution. The danger, he thought, was in the widespread introduction of species from one system or lake to another where it was not endemic. These actions were partly the consequence of steps taken to counter-balance the threat or the fact of the over-fishing of the endemic species. The results were unpredictable because so little was known about the overall ecology of the waters, but they might well upset the bionomy of the lakes. Mr. Greenwood pointed out that some species were known to run up rivers and temporary flood streams to spawn in areas inundated during the biannual rains. Such species were particularly vulnerable to the effects of flood control and irrigation projects. As the future of the two British freshwater stations in Uganda and Rhodesia was by no means assured, he hoped that every effort would be made to ensure their continued existence.

Dr. Peter Crowcroft (British Museum, (Natural History)) reviewed what little information was available about changes in the status of Australian mammals, particularly the small marsupials and native rodents which had been replaced over immense areas by the introduced house mouse and ship rat. The introduction of the European fox constituted one of the greatest threats to many terrestial forms, but the available evidence suggested that the arboreal marsupials were in no danger. It was noteworthy, too, that both the Monotremes, the spiny anteater (*Tachyglossus*) and the duck-billed platypus (*Ornithorhyncus*) were widespread and abundant in the eastern States. Although Tasmania possessed less species, it appeared to have a better chance of preserving them, particularly as the fox had not been introduced. The fate of the thylacine or Tasmanian 'tiger' remained in doubt, but the Tasmanian devil (*Sarcophilus*) was abundant. An important new factor in conservation was the recently formed Australian Mammal Society, which was stimulating research and co-ordinating survey work. This should enable further changes to be assessed with far greater accuracy. The paucity of information about the distribution and numbers of Australian mammals in the last century made it difficult to distinguish between those changes caused by settlement and those which were already proceeding naturally, perhaps as a consequence of climatic changes.

JOHN HILLABY

COLONIAL RESEARCH, 1959-60

*COLONIAL RESEARCH, 1959–60**, follows the pattern of recent reports. It is slightly shorter, due in part to the disappearance of a report from the disbanded Colonial Products Council, which is replaced by a brief report from the Tropical Products Institute of the Department of Scientific and Industrial Research on work done on behalf of Colonial territories. It also includes the fifteenth annual reports of the Committee for Colonial Agricultural, Animal Health and Forestry Research and the Colonial Medical Research Council, the sixteenth annual report of the Colonial Social Science Research Council, the thirteenth annual reports of the Colonial Economic Research Committee and the Colonial Pesticides Research Committee, the fifth annual report of the Colonial Road Research Committee, the annual report on fisheries research of the Colonial Fisheries Advisory Committee and reports from the Tsetse Fly and Trypanosomiasis Committee and the Director of the Anti-Locust Research Centre. Besides the annual report on Colonial research, there is a section dealing with research matters not covered by the reports of the specialist advisory bodies, and this refers to building and housing research, industrial and engineering research, meteorology, and geological surveys, as well as to the work of the Falkland

* Colonial Office. *Colonial Research, 1959–60*: Pp. 381. (Cmnd. 1215.) (London: H.M. Stationery Office, 1960.) 17*s.* net.

Islands Dependencies Survey and of the Man-power Research Unit, Jamaica.

The annual report on Colonial research notes the dissolution of the Colonial Research Council, and afterwards of the Colonial Road Research Committee, in June 1960, and of the Colonial Medical Research Committee, in July 1960. The functions of the former have been absorbed by the new Committee on Overseas Road Research, which will advise the Road Research Board of the Department of Scientific and Industrial Research, and also the Colonial Secretary, on Colonial road research. Those of the latter have been absorbed by the new Tropical Medicine Research Board set up by the Medical Research Council, and the new Board will advise the Colonial Secretary, through the Medical Research Council, on all medical research in and for the Colonies financed from Colonial Development and Welfare Funds. To the work of the Overseas Research Council there is only the slightest reference: the Council is said to be considering the retention and recruitment of scientific staff for work overseas, and it is stated that the Council will be able to call for advice on existing research organizations, including the Colonial Research Advisory Committee; but it is apparent that, while these bodies are to keep the Overseas Research Council informed of their activities, they are to report direct to the Colonial Secretary.

There is, in fact, nothing in *Colonial Research, 1959–60*, to provide the conspectus of overseas research which the establishment of the new Overseas Research Council might be expected to provide, or to indicate that the new Council is likely to be in a position to provide such a conspectus in the near future. Nor can any justification be found in its pages for the change of name, and the dropping of a honoured term to which the Colonial Secretary paid a timely and handsome tribute in the House of Commons in December. It would appear that activities will continue much as before, and there is no hint of the vision and imagination that are required to seize the opportunities that overseas research and technical assistance generally now present.

These opportunities are, in fact, stressed by the substantial increase in Colonial Development and Welfare Research Schemes made during the year. The 134 new schemes and 82 supplementary schemes, involving grants totalling £2,370,261, compare with 71 new schemes and 63 supplementary schemes, totalling £798,974 in the previous year, and brought the total allocation to research schemes since 1940 to £21,864,193. About 42·6 per cent of the £2·37 million granted in 1959–60 was for agricultural, animal health and forestry schemes, 15·8 per cent for medical research, 2·6 per cent for fisheries research, 1·9 per cent for tsetse and trypanosomiasis research, 2·1 per cent for social science economic research, 23·7 per cent for pesticides research, 2·4 per cent for products research, and 7·1 per cent for anti-locust research. About 33·5 per cent of the gross allocation was for schemes to benefit the East African territories, 7 per cent for the West African group, 15·5 per cent for South-East Asian territories and Hong Kong, 12·5 per cent for the West Indian Colonies, British Guiana and British Honduras, 1 per cent for the Central African territories and 30·5 per cent for other territories or for schemes of general interest.

Twenty-four new appointments were made during the year to the Research Branch of the Overseas Civil Service; but the total complement in March 1960 was 199 compared with 207 in March 1959. Two Research Fellows, one studying human trypanosomiasis at the West African Institute for Trypanosomiasis Research, and the other investigating arterial hypertension in Jamaica at the University College of the West Indies, completed their investigations during the year; a third Research Fellow, studying the effect of diet on the levels of various co-factors and enzymes concerned with carbohydrate and fat metabolism at the University College of the West Indies was released from his fellowship for other research work. Two further research fellowships and six research studentships were awarded during the year.

Although, as already stated, *Colonial Research* does not provide the conspectus of overseas research that might be expected and that indeed is essential, the reports of the several specialist advisory committees, besides including a list of publications during the year, contain much information on research activities outside the direct responsibility of the particular committees. That of the Committee for Colonial Agricultural, Animal Health and Forestry Research —much the longest— includes accounts of the work of the several regional research organizations in that field in East and West Africa, and the West Indies and of the Imperial College of Tropical Agriculture, and also accounts of research carried out by the Colonial Departments of Agriculture, Forestry and Animal Health. Similarly, the Colonial Fisheries Advisory Committee reports on the work of the Sierra Leone Fisheries Research and Development Unit, the East African Fisheries Research Organization, Jinga, the East African Marine Fisheries Organization, Zanzibar, the Northern Rhodesian–Nyasaland Joint Fisheries Research Organization, the Tropical Fish Culture Research Institute, Malacca, and the Fisheries Research Unit of the University of Hong Kong. The Colonial Medical Research Committee likewise reports on the work of the regional organizations for medical research, and a research undertaken and financed by the Medical Departments of Colonial Territories, while that of the Colonial Pesticides Research Committee, besides reviewing the work done for the Committee by its research units at Porton and in East Africa, by the Agricultural Research Council's Unit of Experimental Agronomy, Oxford, at Long Ashton Research Station, at Rothamsted Experimental Station, at the Imperial College Field Station, Silwood Park, and by the Herbicide Unit of the Regional Research Centre, Trinidad, gives more than half its space to research not under the ægis of the Committee. The report of the Colonial Social Science Research Council has appended to it the annual reports of the East African Institute of Social Research, the Nigerian Institute of Social and Economic Research, the Institute of Social and Economic Research, the University College of the West Indies and of the Rhodes–Livingstone Institute. The report of the Tsetse Fly and Trypanosomiasis Committee is essentially an account of the work of the regional research organizations in East and West Africa, supplemented by a review of activities of territorial departments, and that of the Director of the Anti-Locust Research Centre on Locust Research and Control is no less essentially an account of regional and co-operative effort.

The material is thus largely available for some authoritative conspectus of research effort overseas and also much evidence of the extent to which that

effort is interlocked with research effort in Britain generally. What is lacking appears to be the authority or the will. If the Minister for Science is indisposed to accept responsibility which appears to arise directly out of his responsibility for the Overseas Research Council and the other Research Councils, the inquiry already set on foot by the Colonial Secretary into the organization of technical assistance can scarcely fail to shatter the present complacency. It may stimulate something of the reappraisal and oversight of the whole of this research effort and its adequacy in relation to existing and future needs and to available resources of man-power as well as of finance that is overdue.

THE PORTUGUESE MAN-OF-WAR

IN a well-produced report on the Portuguese man-of-war*, Mr. A. K. Totton and Dr. G. O. Mackie have written complementary accounts, natural history and morphology by the former, and behaviour and histology by the latter. The two sections are based, partly on material from the *Discovery* collections, and partly on the results of a three-months trip to the Canaries.

Mr. Totton provides a non-technical description of *Physalia* for the layman and goes on to describe its habits, somersaulting behaviour, flotation and motion in relation to wind and water. From experiments at Arrecife he finds that the animal floats with its long axis at an angle of about 45° from the down-wind direction. He does not accept Woodcock's hypothesis that specimens from the southern hemisphere are nearly always mirror images of those from north of the equator, and the following explanation advanced by Mr. Totton appears to be much more satisfactory: "I think that left or right-handedness in a particular individual must be established on the first windy day that the larva keeps to the surface. The larval tentacle would cause a drag on the windward side, so that the float would be blown (so to speak) to leeward. As new tentacles grow. . . this drag would be increased and the part of the float from which they are budded would become bowed out to windward as a bulge, resulting fortuitously in a left- or right-handed individual".

The main part of Mr. Totton's report, however, is a detailed re-investigation of the complex budding pattern in the cormidial groups of appendages, in which he has been able to substantiate and amplify the basic work of Huxley, Lens and van Riemsdijk, Steche and Okada. These structures are described in great detail, and there are many excellent photographs; but this morphological section would have been easier to understand if more stylized drawings (like text-figure 26), as well as stereo-diagrams, had been used to clarify the complicated pattern of budding.

On origins, the author accepts the well-known idea that the ancestral form was a kind of actinula with an apical float and that this became colonial, as implied by Delage and Hérouard (1901, pl. 28). It is further suggested that "the evolution of *Physalia* and the other siphonophores seems to be linked with that of certain corymorphine, myriotheline and margelopsine hydroids; with *Pelagohydra* and with the so-called Disconantha (*Velella*, *Porpema*, *Porpita*)". This is a curious assemblage of forms because the tubularoids (including, *inter alia*, corymorphines and margelopsines), the myriothelines and the so-called Disconantha (Chondrophores) are very distinct hydroid groups. In particular, the Chondrophores have been conclusively shown to be 'pteronemid' hydroids (that is, allied to *Zanclea* rather than *Tubularia*) by Picard, but the author seems to have overlooked this and much other recent work bearing on his problem. Nor does he discuss the possibility of siphonophore evolution from a group other than capitate hydroids, and, in this connexion, the Actinulida have a strong claim for consideration.

There is some confusion in terminology, there being, for example, no distinction drawn between a hydromedusan gonozooid (medusa or medusa bud) and a disconanth gonozooid (reproductive hydranth bearing medusa buds). It is also surprising to find that the author equates "an asexual replicated gonozooid of *Velella*" with a blastostyle of *Climacocodon*. Dr. Mackie (p. 372) also promotes this same view that the blastostyles of *Corymorpha* and the reproductive polyps of *Velella* "are alike and homologous in every respect", but this interpretation is unlikely to be acceptable to hydroid specialists.

On the association of the fish *Nomeus* with *Physalia*, Mr. Totton does not discuss a new interpretation of the immunity of some fish to coelenterate stings put forward by Davenport and Norris. These authors, working on *Amphiprion* and the sea anemone *Stoichactis*, demonstrated that while the thick mucus covering of the fish remains intact, the nematocysts are not stimulated, but once this is removed (as with contact with a net) the fish is vulnerable. Some such mechanism may protect *Nomeus*.

Dr. Mackie's plan to investigate the behaviour and reactions of *Physalia* was broadened to include also histology in order to establish, in particular, the extent of the nervous co-ordination between the different parts of a siphonophore colony. He was able to examine the muscular and nervous systems, the mesogloea, the gas gland, the nematocysts and the histology of the digestive regions, the whole being a valuable contribution to siphonophore biology.

In specimens of *Physalia* exposed to the wind, the crest or sail is erected, and, although the way in which the wind acts has not been determined, any stimulus causing an overall tightening of the float musculature will normally result in crest erection. Dr. Mackie aptly describes the mechanism as reminiscent of a pneumatic tyre with an inflatable rubber tube—the tube corresponding, of course, to the pneumosaccus inside the float.

Space does not allow full consideration of these exceptionally well-illustrated reports, but the fate of the gonophores, the great puzzle in *Physalia*, remains unsolved; it is suggested that the eggs undergo development in the depths.

W. J. REES

* *Discovery Reports*: Vol. 30, Pp. 301–408, Plates 7–28. August 1960: Studies on *Physalia physalis* (L.). Part 1: Natural History and Morphology. Part 2: Behaviour and Histology. By A. K. Totton and G. O. Mackie. (Cambridge: At the University Press, 1960.) 70*s.* net.

BIRTH OF DELINQUENTS

ALTHOUGH a connexion between economic depressions and other social catastrophes—such as war—with the origin of delinquency in children has long been suspected, little statistical evidence to support the hypothesis has been available. The evidence is now brought out in a report published by the Home Office Research Unit, entitled *Delinquent Generations**, which shows that the peak of the effect is shown to occur not for those children born during the 1939–45 War, but for those born during 1935–42. These are children a large proportion of whom passed through their fourth to fifth year during the War, suggesting that the social disturbances which occur during the fourth and fifth year of life may have a greater effect than at other ages.

The analysis is based on criminal statistics for the period 1946–57 for each year of birth from 1925–26 to 1948–49. The argument is developed from simpler analyses to a complex process of standardization. In the first place the crime-rate for eight-year-old male offenders is followed from 1946 to 1957, and this shows that the crime-rate was least (for this age) when the number of children of that age was greatest; the statistical work also shows that, for children born after the War, there is a positive correlation between the number of children of a given age at risk and the crime-rate for that age, whereas for pre-War births the tendency is towards a negative correlation.

In 1948, with one of the smallest populations of eight-year-old boys, the crime-rate for this age was the worst for any year of the period studied. There was a continuous and marked improvement until 1956, with 1955 showing the lowest crime-rate (together with the peak of the population bulge). Not only did eight-year-old boys have the worst crime-rate in 1948 but also the highest crime-rate for seventeen-year-old boys occurred in 1957, when this same generation was seventeen years old.

Analyses of this kind are then generalized for all ages from eight to twenty years of age, for both males and females separately in England and Wales, and for males in Scotland. It is interesting to find that the same patterns of crime-proneness apply to both sexes and to both Scotland and England, notwithstanding that the rates at different ages are not at all similar.

Another finding is that youths between seventeen and twenty-one in 1955 and onwards, who would, according to the general findings of this research, have been expected to be exceptionally delinquent because of the effects of the War, have in fact been even more delinquent than could have been predicted. Either some new and different factor has operated during recent years, or the earlier influences have an additional effect at adolescence.

* Home Office. *Delinquent Generations*: a Home Office Research Unit Report. (Studies in the Causes of Delinquency and the Treatment of Offenders, No. 3.) By Leslie T. Wilkins. Pp. iv+19. (London: H.M. Stationery Office, 1960.) 1*s.* 6*d.* net.

BILHARZIASIS

WHILE economic development usually reduces general morbidity, it has been found in a number of countries that improvement of irrigation networks has resulted in the spread of bilharziasis. Ways of dealing with this growing menace were studied at the second African conference on "Bilharziasis", convened jointly by the World Health Organization and the Commission for Technical Co-operation in Africa South of the Sahara, and held during March 30–April 8, 1960, in Lourenço Marques. The report, which has just been published, constitutes a general assessment of the present bilharziasis control situation in Africa where "the pressing problems of control are related rather to the deployment of skills, materials and work than to the uncertainty of methods"*.

Assessment of morbidity is complicated by the chronic nature of the disease which may be recognized only if it entails a period of incapacitation for work. Of the three phases of the disease described in the report, the conference considered the last—that of irreversible pathological effects and *sequelae*—to be by far the most significant from both the public health and the socio-economic point of view. The report directs attention to the pulmonary effects of *S. haematobium* infection, and to the fact that eggs may sometimes be recognized in the sputum of patients. Methods of assessing morbidity are reviewed, and the advantages of certain methods brought out.

The merits of the various types of classic molluscicide (copper sulphate, pentachloriphenate) and also of the more recent products (Bayer 73, I.C.I. 24223, and 'Aqualin') are examined, together with ways in which these products are used in African territories. Water management, land use and agricultural practices were examined at length in relation to the transmission and spread of bilharziasis. Some countries in the African region have adopted legislation relating to the control of communicable diseases, and the report cites an example of one law which might be modified and adapted to local health and economic conditions elsewhere. Methods of irrigation and agriculture and of bilharziasis control aspects of engineering techniques applied to watercourses, ponds and reservoirs are studied, and the frequently neglected possibility of using rainwater is also touched on.

In addition to the steps taken to improve irrigation plans, it would be desirable to construct bridges and culverts, to install safe washing and bathing places and at the same time to develop an effective health education programme so that people may be made aware of the danger of natural waters.

* World Health Organization. Technical Report Series No. 204: Second African Conference on Bilharziasis (WHO/CCTA), Lourenço Marques, Mozambique, 30 March–8 April, 1960—Report. Pp. 37. (Geneva: World Health Organization: London: H.M. Stationery Office, 1960.) 1 Swiss franc; 1*s.* 9*d.*; 0.30 dollars.

VELOCITY OF LIGHT IN A MAGNETIC FIELD

By Prof. THOMAS ERBER

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RECENT advances in several areas of technology, in particular the production of very high steady ($\sim 0{\cdot}25$ megagauss) and pulse-imploded (~ 30 megagauss) magnetic fields, have brought closer the prospect of the experimental observation of a number of vacuum polarization effects. It seems appropriate at this time to make a preliminary survey of some of these possibilities and to provide some evaluation of their technical feasibility.

I begin by recalling that non-linear electromagnetic effects enter quantum electrodynamics essentially through the diagram presented in Fig. 1. This depicts schematically the dissociation of a photon into an electron-positron pair, usually virtual, which is afterwards annihilated to re-create a photon. The arrow symbolizes an external electromagnetic field (it may be another photon) which exchanges energy and momentum with the pair in the intermediate state. In this sense quantum electrodynamics gives rise to light-light and light-field interactions.

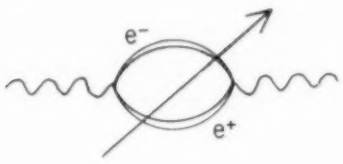

Fig. 1

Suppose the original photon is propagated in the z-direction and that the arrow represents a constant magnetic field the lines of flux of which are in the y-direction. One then finds that the real part of the index of refraction of the vacuum stressed by the external field is given by[1-3]:

$$n = 1 + \frac{\alpha}{4\pi}\left[\frac{B}{B_{cr}}\right]^2 N(\chi) \qquad (1)$$

where:

$$\alpha = \frac{e^2}{\hbar c} \sim \frac{1}{137};$$

$$B_{cr} = \frac{m^2c^3}{e\hbar} = \alpha\,\frac{e}{r^2} \sim 4{\cdot}5 \times 10^{13}\ \text{gauss};$$

$$\chi = \frac{h\nu}{mc^2}\cdot\frac{B}{B_{cr}};$$

ν is photon frequency; m, electron mass; B, external field (gauss); r, classical electron radius. $N(\chi)$ is a very weakly varying function of χ in almost the entire range of practical interest. For photons polarized in the direction of B, that is, the y-axis, one may take $N(\chi) \sim 0{\cdot}2$ in the range $0 < \chi < 0{\cdot}1$; for photons polarized perpendicularly to B a similar approximation gives $N(\chi) \sim 0{\cdot}3$. Further details are contained in Toll's thesis[3].

I now consider a number of applications:

(1) *Cotton-Mouton effect:* Equation (1) essentially says that there is a selective slowing down of light in a transverse magnetic field. By using polarized light and exploiting $N_{\parallel} \neq N_{\perp}$ one can achieve a rotation of the plane of polarization. This is in complete analogy to the transverse double refraction of optically active media (even to the B^2 dependence) and therefore deserves to be called a 'Cotton–Mouton' effect. From these remarks it follows readily that θ, the angular rotation of the plane of polarization (radians) is given by:

$$\theta \simeq \frac{\alpha}{15}\,\frac{l}{\lambda}\left(\frac{B}{B_{cr}}\right)^2 \qquad (2)$$

where l is the path-length and λ is the wave-length. The key point of this approach is the enormous help of the factor l/λ. Assuming a field of 3×10^7 gauss[4] and a path-length of about 10^2 cm. one finds:

$$\theta \simeq \frac{1}{2\lambda}\ 10^{-13}\ \text{radians} \qquad (3)$$

At this point it is clear that it would be advantageous to choose a λ well into the γ-ray region. Unfortunately the experimental means for measuring θ are very poor at these frequencies. Since the pulse-imploded fields cannot be maintained for periods longer than about 1μ sec., the accurate γ-ray polarimetry possible with the Mössbauer effect cannot be used.

In the optical range one sacrifices λ but has some compensating advantages: (*a*) The short working times permitted by the pulsed fields are no longer prohibitive since rapid shuttering (Kerr cells) and sufficient intensities are available. (*b*) Path folding techniques may be used for maximum exploitation of the available magnetic volume. (*c*) Very precise measurements of θ, probably down to at least $\sim 5 \times 10^{-7}$ radians, are possible[5]. It seems likely that a moderate extension of present techniques would make the experiment represented by (3) feasible in this region.

(2) *Refraction of light:* Experiments of this type have the unique advantage of not requiring large field volumes; the non-linearities arise from the mere presence of an interface between a field and field-free region of space. This is particularly suited to the pulse-imploded fields since their strong point is the creation of a magnetic 'shock' travelling ahead of the detonation wave. By suitable arrangement of the explosive charges it should be possible to focus these magnetic waves and enhance the non-linearities through field superposition. The observation of refraction effects then becomes the analogue of ordinary schlieren photography.

An extraordinarily sensitive refraction experiment of this kind has been performed by Jones[6]: Using a static magnetic field of 8000 gauss shaped in the form of a prism with apex angle $\sim 100''$, he looked for a deviation with a 'light lever' capable of sensing an angular deflexion $\sim 5 \times 10^{-12}$ radian. In this case:

$$\Delta n \equiv n - 1 \simeq \tfrac{1}{2}\delta > 10^{-12} \qquad (4)$$

where δ is the angle of deflexion. No effect was observed. For such feeble fields this follows readily from (1): We have directly that:

$$\Delta n \simeq B^2 \times 10^{-13} \sim 6{\cdot}4 \times 10^{-24} \qquad (5)$$

which is many orders of magnitude below the limit set by (4). Even for the largest static field configurations at present contemplated[7] $\Delta n \sim 6 \times 10^{-21}$, which is still far too small. For the pulse-imploded fields, however, $\Delta n \sim 10^{-16}$, and this begins to come into the realm of practicability. It remains to be seen whether the development of intense pulsed optical maser (laser) sources will facilitate the construction of sensitive 'fast' levers.

(3) *Interferometric experiments:* These are among the most straightforward means of detecting a variation in Δn. With conventional interferometer arrangements:

$$\Delta n \equiv \beta \lambda / l \qquad (6)$$

where β is the fringe shift and l denotes the effective interferometer length. Assuming values of $l \sim 10^2$ cm., $\lambda \sim 5 \times 10^{-5}$ cm., and an optimal β of about 10^{-3}, one estimates[8]:

$$\Delta n \sim 5 \times 10^{-10}$$

Comparing with (5) it becomes evident that this is at least six orders of magnitude too large. This experiment has already been tried by Farr and Banwell[9] using a static transverse field of about 20,000 gauss; essentially no detectable shift in Δn could be established. It is interesting to note that Jones's gain of 10^2 in absolute accuracy is partially off-set by a factor of 1/6 in relative accuracy due to the lower field intensity. This emphasizes again the crucial importance of high field strengths in the detection of non-linear effects.

Interferometric techniques will undoubtedly reap great benefit from the introduction of coherent sources of optical radiation. Unfortunately it does not seem likely that this will make the velocity-shift experiments any easier. Laser sources will simply relax the present limitations on l; this still leaves the very considerable problem of providing expensive and elaborate equipment for manufacturing large magnetic volumes. A likelier avenue of improvement lies along an increase in the accuracy of measuring phase shifts. Coherent light could in principle be heterodyned to produce signals in a convenient radio-frequency range; rapid β-determinations down to about 10^{-4} would then seem to be feasible[10].

(4) *Dispersion effects:* The abrupt shift in the accepted value of the velocity of light (a change of about 5 parts in 10^5) brought about by the introduction of radar techniques during the Second World War has given rise to a persistent undercurrent of speculation about a possible dispersion in the velocity of light. (See for example the discussion in Ditchburn[11].) Recently Softky and Squire[12] have proposed a test of this hypothesis using a nuclear explosion in outer space. The blast would produce a sharply defined pulse of wide-band radiation. It is estimated that by clocking the difference in arrival time of radio-frequency- and γ-rays over a baseline of 2 light-seconds, a dispersive effect of less than one-twentieth of the 'post war' shift (across a frequency spread of 10^{11}) could be reliably detected.

Theoretically speaking such an effect is already contained in the weak dependence on frequency of $N(\chi)$ of (1). (It is important to note that an external field is always required to produce dispersive effects in the Euler–Kockel Lagrangian[1].) Unfortunately even with a generous estimate of 10^{-4} gauss for the effective fields encountered in traversing the interplanetary baseline, the incremental arrival times would be only about $2\Delta n \sim 10^{-26}$ sec., that is, far beyond present instrumental resolution. Any measurement of $\Delta n(RF)/\Delta n(\gamma)$ along these lines would seem to be out of the question in the foreseeable future.

Conversion to frequency shift: Present experimental technique excels in the precise determination of frequency. It would seem most attractive therefore to measure minute velocity shifts in terms of a frequency shift. If indeed $\Delta v/v \sim \Delta n$ then according to (5) one would merely require an accuracy of $\Delta v/v \sim 10^{-16}$, which is not at all unreasonable in the light of what has already been achieved in connexion with the Mössbauer effect. Unfortunately, specific schemes for velocity to frequency conversion, quite apart from all instrumental difficulties, seem to involve unfavourable proportionality factors which increase the sensitivity requirements on $\Delta v/v$ still further. I consider briefly two possibilities, the Doppler effect and γ emission: (i) In a typical Doppler shift experiment, for example the reflexion of light from a moving mirror, one obtains a relative frequency shift given by:

$$\frac{\Delta v}{v} = 2\frac{v}{c}$$

where v is the mirror velocity. Suppose that the experiment were also carried out in a very strong ambient field (H) the sole effect of which is to decrease the velocity of light. In this case one should find a slightly different shift since it is the ratio of the mirror velocity to the actual light velocity that enters. The net change is:

$$\frac{\Delta v}{v}(H) - \frac{\Delta v}{v}(0) = 2\frac{v}{c}\Delta n \qquad (7)$$

which shows clearly that in this type of conversion experiment the minute effects of Δn are diminished even further by the presence of the factor v/c. (ii) Another method of converting the velocity shift to a frequency shift hinges on the relationship between the energy and momentum of a photon: $cp = h\nu$. To first order it may be assumed that it is only the photon momentum and not the photon energy which is affected by the presence of an external field. In order to obtain a frequency shift it is necessary to consider a decay process so that the final photon frequency is fixed by both the energy and momentum balance. In calculating this there is some ambiguity involved in carrying through the relativistic kinematics in an anisotropic space but the net frequency shift fortunately is insensitive to the details of the assumptions. I find:

$$E_r(H) - E_r(0) = \frac{E_1}{E_0}\Delta n \qquad (8)$$

where E_1 is the energy available in the γ transition; E_0 is the rest energy of the residual nucleus; and $E_r = (E_1 - h\nu)/E_1$ is the fractional recoil shift of the emitted γ-ray. In this case it is also evident that any effects due to Δn will be minimized by the presence of the unfavourable conversion factor E_1/E_0.

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ENUMERATION OF COMPONENTS IN COMPLEX SYSTEMS BY FLUORESCENCE SPECTROPHOTOMETRY

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THE constancy of the spectral distribution of the fluorescence for a given substance excited with light of different wave-lengths permits the development of a simple quantitative criterion for the determination of the number of independent fluorescent components in a mixture and also results in an interesting extension of the concept of resolution as commonly applied in spectroscopy.

In fluorescence spectrophotometry a number of fluorescence intensity measurements are made, following excitation with different wave-lengths. Both fluorescence observation and excitation cover discrete wave-bands. Continuously recorded fluorescence and fluorescence-excitation spectra are to be considered here as finite series of measurements with effective band-widths determined by the conditions used[1]. In either case the results may be set down as an $m \times n$ matrix, where the m columns are determined by the wave-lengths of excitation and the n rows by the wave-lengths of observation. The matrix elements, F_{ij}, are numbers proportional to the response of the detector, that is, photocurrents in the ordinary case. The i, j element of this EF matrix, as I propose to call it, is the fluorescence emitted at wave-length j on excitation with light of wave-lengths i. When several components are present in a mixture the EF matrix may be written as:

$$|EF|_{mn} = \begin{vmatrix} \sum_k F_{11}{}^k & \sum_k F_{12}{}^k & \cdots & \sum_k F_{1m}{}^k \\ \sum_k F_{21}{}^k & \sum_k F_{22}{}^k & \cdots & \sum_k F_{2m}{}^k \\ \cdots & \cdots & \cdots & \cdots \\ \sum_k F_{n1}{}^k & \sum_k F_{n2}{}^k & \cdots & \sum_k F_{nm}{}^k \end{vmatrix} \qquad (1)$$

The superscript k refers to the different components. Of the quanta absorbed in the solution from the exciting beam at wave-length i, a fraction $f_i{}^k$ will correspond to the k'th component, while the fluorescence emission by the same component at wave-length j is denoted by the absolute quantum yield at this wave-length band $q_{ij}{}^k$, where the subscript i is also present to describe the possible, though rare[1,2], eventuality of change of quantum yield with exciting wave-length. Consequently:

$$F_{ij}{}^k = A_i f_i{}^k B_j q_{ij}{}^k \qquad (2)$$

A_i is a row multiplier that stands for the absolute number of exciting quanta absorbed at wave-length i, and B_j a column multiplier proportional to the detector response to a quantum of radiation of j wave-length. A and B can therefore be eliminated from the matrix without affecting the properties in which we are interested, and the EF matrix may be written as:

$$|EF|_{mn} = \begin{vmatrix} \sum_k f_1{}^k q_{11}{}^k & \sum_k f_1{}^k q_{12}{}^k & \cdots & \sum_k f_1{}^k q_{1m}{}^k \\ \cdots & \cdots & \cdots & \cdots \\ \sum_k f_n{}^k q_m{}^k & \sum_k f_n{}^k q_{n2} & \cdots & \sum_k f_n{}^k q_{nm} \end{vmatrix} \qquad (3)$$

An arbitrary 2×2 minor of the matrix is:

$$|EF|_{ij} = \begin{vmatrix} \sum_k f_i{}^k q_{ij}{}^k & \sum_k f_i{}^k q_{il}{}^k \\ \sum_k f_n{}^k q_{nj}{}^k & \sum_k f_n{}^k q_{nl}{}^k \end{vmatrix} \qquad (4)$$

If the spectral distribution of the fluorescence is independent of the exciting wave-lengths as appears to be in all known cases of substances in solution,

$$\frac{q_{ij}{}^k}{q_{il}{}^k} = \frac{q_{nj}{}^k}{q_{nl}{}^k} = R_{jl}{}^k \qquad (5)$$

and the value of the last determinant becomes:

$$\Delta = \left(\sum_k f_i{}^k q_{il}{}^k R_{jl}{}^k\right)\left(\sum_k f_n{}^k q_{nl}{}^k\right) - \left(\sum_k f_i{}^k q_{il}{}^k\right)\left(\sum_k f_n{}^k q_{nl}{}^k R_{jl}{}^k\right) \qquad (6)$$

Thus the important rule follows that all the 2×2 determinants of the EF matrix are zero when: (1) There is a single fluorescent component in the solution, whether the absorption is due to one or more components ($q_{ij}{}^k = 0$, for $k > 1$). (2) There is more than one fluorescent species in the solution, but they all possess the same absorption spectrum ($f^1 = 1, f^k = 0$, for $k > 1$). This obviously provides for the possibility of demonstrating the appearance of a new fluorescent species during the life-time of the excited state.

Because of the fixed ratios of the q-values for each component independently of the exciting wave-

length (equation 5), it follows that when there are two independent components in the solution the second-order determinants of the EF matrix will not all vanish, but the 3×3 determinants will vanish identically, and in general, the rank of the EF matrix gives the number of components in the system having distinct absorption and fluorescence spectra. Conversely, the 'purity' of a fluorescent solution can be tested and the presence of fluorescent impurities detected by observing whether the 2×2 minors of the EF matrix vanish. Moreover, the non-vanishing determinants cover the region over which both fluorescence and absorption spectra differ and can be used to single out such a region.

In practice the determinants will not exactly vanish, but approach zero within the experimental error of the method. If the average photocurrent involved in a 2×2 determinant is $F \pm \delta F$, then a zero determinant will appear to have the value :

$$\Delta = 0 \pm 2\bar{F}\delta F; \quad \frac{\Delta}{P} \simeq \frac{\delta F}{F} \qquad (7)$$

where P is the permanent or value resulting from adding all the determinant products, so that for the 2×2 determinant, $P \simeq 2\bar{F}^2$. The last equation permits one to evaluate significant departures from nullity. A ratio of determinant to permanent of 3 times the coefficient of variation of the measured photocurrents can be considered significant. Moreover, the appearance of the non-zero values over compact regions of the spectrum as well as the constancy of sign can be used to refine the criteria for nullity. The value of the determinant will depend on both f and q, and by the use of equation 6 it is possible to see that in favourable cases it will be possible to detect an impurity present as a molar fraction of the total much smaller than the ratio Δ/P.

In agreement with the usual spectroscopic criterial a fluorescence spectrum may be called partially resolved into components, if there are spectral regions which can be demonstrated to belong to each component separately. In a spectrum of two components (2×2 minors non-zero, 3×3 minors $= 0$) the spectrum will be partially resolved, if there is at least one region where all 2×2 determinants are zero, when both the fluorescence wave-bands are selected from this region, and the exciting wave-lengths chosen arbitrarily, but some 2×2 determinants are non-zero when only one component is selected from within the region.

In the experimental use of the EF matrix two possible causes of error must be given consideration : the fluorescence spectrum may appear to change with exciting wave-length if the absorption of the exciting radiation becomes weaker than or even comparable to the absorption of any of the observed fluorescence wave-bands by the solution. Also, scattering of the exciting radiation may have a similar effect by adding a short-wave component to the fluorescence, when the wave-bands of excitation and observation become too close to each other. With good monochromators, it is possible to bring these two band-widths very near the theoretical limit. In one of the experiments quoted below, the wave-lengths of observation and excitation were brought within 13 mμ while the sum of the band-widths was 6 mμ, without impairing the results.

The detector response must be linear within the range of photocurrents measured, otherwise the spectrum will appear to change, depending on the signal strength, or in other words B_f will not be a true column multiplier but a function of q. In practice, the detector response must be kept constant through the series of measurements of either rows or columns of the EF matrix. In the former case, a series of excitation spectra of defined fluorescence bands is obtained; in the second, a series of fluorescence spectra excited by definite wave-bands is obtained.

Two examples are given below of the usefulness of the matrix treatment of the data of fluorescence spectrophotometry. The first example refers to the fluorescence of human serum albumin. This protein contains seventeen tyrosine and one tryptophan residue, all potentially capable of fluorescence[3], although in previous work no contribution from the tyrosine was detected[4], and the whole emission was attributed to the single tryptophan. The EF matrix obtained with a solution of human serum albumin at neutral pH is given below. The wave-bands for excitation and observation were both 3·0 mμ.

		Excitation wave-lengths (mμ)		
		275	285	295
Observation wave-lengths (mμ)	308	66	89	65
	325	100	141	205
	350	108	153	290

The value of the 3×3 determinant/3×3 permanent is 0·002 or zero within error. Thus, there are less than three distinct components detectable. The 2×2 minors are analysed in the following table which gives the ratios of Δ/P for each pair of excitation and observation wave-lengths :

		Excitation pairs	
		275–285	285–295
Observation pairs	308–325	+ 0·022	+ 0·35
	325–350	+ 0·003	+ 0·135

The presence of two distinct components in the absorption and fluorescence is clear, since the experimental error in the determination of the photocurrents was about 1 per cent. From the signs of the two by two determinants it can be concluded

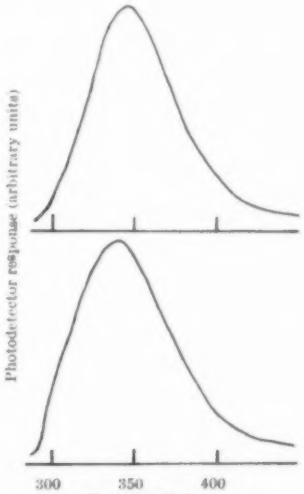

Fig. 1. Fluorescence spectra of 0·5 per cent solution of human serum albumin in water. Excitation and fluorescence band-width of 2 mμ. Upper figure excited at 292 mμ ; lower excited at 278 mμ. All spectra shown are direct recordings uncorrected for grating transmission or photodetector (*EMI* 6255) response

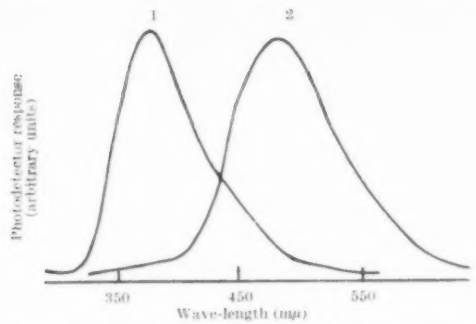

Fig. 2. Fluorescence spectra of 10^{-2} *M* sodium naphthionate in water. Excitation at 340 mμ. Band-widths 2 mμ. (1) Neutral solution; (2) 3 *N*, sodium hydroxide solution

that the component increasing its absorption fraction over the 285–295 mμ region is the one emitting at the longer wave-lengths as expected from tryptophan. The minors for 275–285 excitation are virtually zero, showing that there is no change in the fractional absorption of the two components over this interval. Following the indications given by the matrix treatment, fluorescence spectrum recordings using narrow bands of excitation at 278 and 292 mμ were undertaken and are shown in Fig. 1, where the contribution from tyrosine appears clearly as a shoulder on the short-wave side of the spectrum, excited at 278 mμ and is virtually absent in the spectrum excited with 292 mμ. The absolute quantum yield of the tyrosine is estimated as between 0·015 and 0·025.

The matrix treatment has also been applied to the fluorescence data from alkaline solutions of sodium naphthionate. The fluorescence spectrum of this compound in neutral solution has a maximum at 395 mμ, while in 2*N* sodium hydroxide the maximum is found at 502 mμ, both spectra being as shown in Fig. 2. Boaz and Rollefson[5] and Förster[6] have concluded from their work on this and similar compounds that the fluorescence shift is due to abstraction of a proton from the amino-group during the lifetime of the excited state so that the long-wave fluorescence is due to the NH^- ion, a species virtually non-existent in the ground-state. The *EF* matrix given below was obtained with a moderately alkaline solution in which both fluorescence bands were present to about the same extent (Fig. 3):

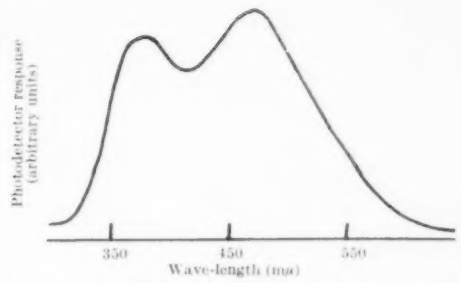

Fig. 3. Fluorescence spectrum of weakly alkaline solution of sodium naphthionate

		Excitation wave-lengths (mμ)			
		280	300	340	360
Observation wave-lengths (mμ)	400	81	91	68	98
	450	78	88	66	95
	500	74	83	63	91
	550	43	48	37	53

All nine independent 2 × 2 minors are zero within experimental error, confirming that there is a single species in the ground-state in spite of the complex fluorescence spectrum.

The examples examined show one of the potentialities of fluorescence spectrophotometry as compared with absorption spectrophotometry. In the latter, the determination of the number of components cannot be done without reference to the absorption spectrum of the pure species while in fluorescence spectrophotometry this determination is always possible in principle and may be expected to be practically possible in most cases.

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ABSENCE OF PHOSPHATASE REPRESSION BY INORGANIC PHOSPHATE IN SOME MICRO-ORGANISMS

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THE formation of alkaline phosphomonoesterase in strains of *Escherichia coli*[1,2] and *Bacillus subtilis*[3] has been observed to be repressed in a medium containing inorganic phosphate. It was suggested that phosphate, which is a product of phosphatase action, controlled the level of enzyme synthesis via a negative feed-back system[3]. Such a phosphate–phosphatase regulatory system conceivably could play an important part in the phosphorus economy of the cell. In order to determine if this mechanism applied as well in other organisms and to the acid phosphatases, the effect of inorganic phosphate on the formation of both acid and alkaline phosphatase was studied in various strains of *E. coli* and *Staphylococcus aureus*, and in a fungus, *Neurospora crassa*.

Various strains of *E. coli* were grown in a medium containing per litre: 0·1 gm. crystalline magnesium sulphate, 1·0 gm. ammonium sulphate, 0·5 gm. sodium citrate, 10·0 gm. glucose, 12·2 gm. *tris*-(hydroxymethyl)-aminomethane and thiamine or

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amino-acids, as necessary, to the auxotrophic strains; the *p*H was adjusted to 7·4. The growth medium for coagulase-negative staphylococci contained per litre: 0·04 gm. crystalline magnesium sulphate, 0·001 gm. sodium chloride, 0·001 gm. crystalline ferrous sulphate, 0·02 gm. crystalline manganese sulphate, 1·0 gm. glucose, 1·0 gm. yeast extract (Difco), 12·2 gm. *tris*-(hydroxymethyl)-amino-methane, and *p*H was adjusted to 7·4. The coagulase-positive staphylococci were grown in a medium containing glucose, casein hydrolysate, cystine, salts, thiamine and nicotinic acid in the amounts recommended by Evans[4] except that 12·2 gm. of *tris*-(hydroxymethyl)-aminomethane/litre replaced the inorganic phosphate. All three media also contained 10 μgm. phosphorus/ml. as potassium dihydrogen phosphate. The bacteria were subcultured once before inoculating into the growth media, and incubated at 37° C. on a rotary shaker. Alkaline phosphatase was assayed, after an autolysis with toluene, by the method described by Horiuchi *et al.*[5], with minor modification. The reaction mixture was incubated for 30 min. at 30° C., and *p*-nitrophenol liberated was determined by the procedure of Bessey *et al.*[6]. Acid phosphatase was assayed in the same manner in *p*H 5·6 acetate buffer. The optical densities of cell populations were measured using filter 50 in a Klett–Summerson photometer while inorganic phosphate in the medium was determined by the procedure of Fiske and SubbaRow[6].

Neurospora crassa strain 5297*a* was grown for 48 hr. in a synthetic medium[7] on a rotary shaker at 30° C. The mycelium was then blended aseptically for 30 sec. in a Waring blender and aliquots of the suspension were used to inoculate groups of duplicate flasks containing medium in which the level of potassium dihydrogen phosphate was reduced to 43 μgm. phosphorus/ml. After incubation on the shaker at 30° C., replicate flasks were removed at appropriate intervals of time and the mycelium was harvested by filtration, pressed dry and weighed. Aliquots of the filtered medium were also assayed for inorganic phosphate and phosphatase activity. The weighed mycelia were triturated in a cold mortar with 8 parts (w/w) of washed fine glass beads, and the enzyme was solubilized in distilled water. The supernatant fluid obtained after centrifugation was used for assay of both acid and alkaline phosphatase activities using sodium β-glycerophosphate as the substrate[8].

The effect of inorganic phosphate on alkaline phosphatase formation is shown along with the growth curves of two typical *K*12 strains of *E. coli* in Fig. 1. In strain *K*40, alkaline phosphatase formation took place only in the absence of extracellular inorganic phosphate whereas strain 180 formed the enzyme early in its growth while inorganic phosphate was still present in the medium. Addition of phosphate to a culture of strain *K*40 actively synthesizing alkaline phosphatase resulted in the complete repression of alkaline phosphatase, but not general protein synthesis, whereas in strain 180 there was a stimulation of phosphatase synthesis. These findings in strain *K*40 are consistent with what has been reported by previous workers in *E. coli* strains *K*12, *ML* and *W*[1] and strain *B*[2]. On the other hand, the absence of a phosphate-repressible alkaline phosphatase, as found in strain 180, has previously not been reported. The results of similar experiments with various *E. coli* strains are summarized in Table 1. Only three of ten strains tested were found to have a phosphate-repressible alkaline phosphatase, and at least one strain of each mating type, *Hfr*, *F*+, and *F*−, was not repressible, suggesting there is no direct relationship between phosphate repressibility and mating type. None of the strains had a phosphate-repressible acid phosphatase, in agreement with the findings of Torriani[1]. Strain differences are known to exist in other repressible systems. Thus, Gorini[9] reported that in only two of four strains of *E. coli* tested was arginine a repressor for ornithine transcarbamylase.

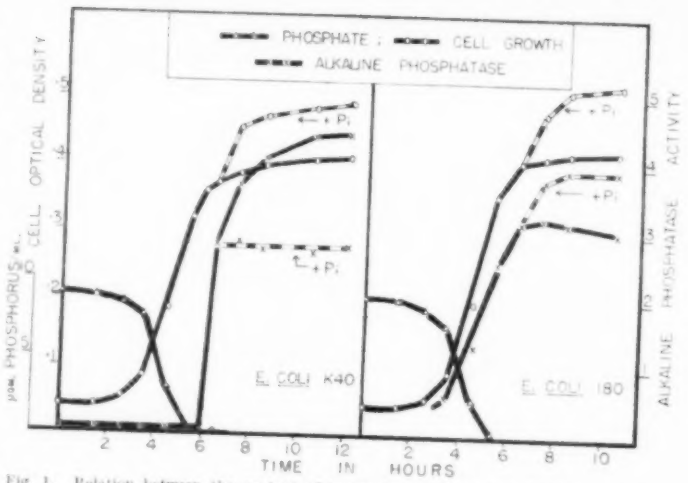

Fig. 1. Relation between the content of inorganic phosphate and the formation of alkaline phosphomonoesterase in two *K*12 strains of *E. coli*. Cells were grown as described in the text. At zero time, 2 ml. of a 12-hr. culture of *E. coli* was inoculated into flasks containing 100 ml. of the synthetic medium in which the phosphorus content was 10 μgm./ml. Samples were withdrawn for determination of cell population, inorganic phosphate (Pi), and alkaline phosphatase at the indicated time intervals. After 6 hr., the inorganic phosphate in the medium was completely utilized and the flasks were divided into two groups. One group received 50 μgm. phosphorus/ml., as potassium dihydrogen phosphate, while the other group received none. Determination of cell population and alkaline phosphatase was continued for another 6 hr. The alkaline phosphatase is plotted in relative units

The amount of phosphatase produced by *Staphylococcus aureus* has been correlated with coagulase production as a biochemical index of pathogenicity[10]. In a recent survey of more than 100 strains of this organism growing in a complex medium, Pan and Blumenthal (unpublished results) found that the average amount of acid phosphatase produced by coagulase-positive strains was about four times greater than that produced by the average coagulase-negative strains. To test the possibility that a phosphate-repressible acid or alkaline phosphatase system was operative in the staphylococci, 17 coagulase-negative and 3 coagulase-positive strains were tested. The results, presented in Table 1, indicate that a phosphate-repressible system could not be detected in any of the strains.

The results of an experiment with a wild-type strain of *N. crassa* are presented in Table 2. The

Table 1. Distribution of Repressor Effect of Inorganic Phosphate on Phosphatase Synthesis in Strains of *E. coli* and *S. aureus*

Strain			Repressor effect	
			Alkaline phosphatase	Acid phosphatase
Escherichia coli	*B*		−	−
	B/r		+	−
	ML30		+	−
*K*12 strain	*K40*	*Hfr*	+	−
" "	*CR63*	*F+*	−	−
" "	173 (W3350)	*F−*	−	−
" "	179* (C600)	*F+*	−	−
" "	180* (112)	*Hfr*	−	−
" "	422*	*Hfr*	−	−
" "	444* (C38)	*F−*	−	−
Staphylococcus aureus†	291	(coagulase +)	−	−
	198	(coagulase +)	−	−
	1-*D*	(coagulase −)	−	−
	314	(coagulase −)	−	−
	B-21-6	(coagulase −)	−	−
	B-10-1	(coagulase −)	−	−

* Auxotrophic strains requiring thiamine and/or amino-acids.
† Total of 20 strains (17 coagulase-negative) tested with same results.

amounts of both acid and alkaline phosphatases, which were present only in the mycelia, were found to be approximately proportional to the cell weight throughout the course of the experiment. The presence of extra-cellular phosphate did not repress the enzyme formation and the phosphatase formation did not increase significantly even after the depletion of phosphate from the medium. This strain of *N. crassa*, therefore, was a non-repressible strain.

Although it is likely that in the future other micro-organisms will be found with phosphate-repressible alkaline phosphatases, the absence of such a system in 20 strains of *S. aureus*, 1 strain of *N. crassa* and 7 of 10 strains of *E. coli* indicates that this is not a common property of micro-organisms. Even closely related strains, like those derived from *E. coli* *K*12, differ in this respect. It therefore seems unlikely

Table 2. Effect of Inorganic Phosphate on the Cell Growth and Phosphatase-Levels in *Neurospora crassa*

Time (hr.)	Mycelial weight (wet) (gm.)		Total acid phosphatase (units*)		Total alkaline phosphatase (units*)	
	−P†	+P†	−P	+P	−P	+P
12	0·320		2·4		1·0	
25	0·616	0·933	4·5	6·6	2·1	4·3
47	0·693	1·178	5·1	8·2	2·6	5·9
67	0·766	1·790	6·5	17·5	3·5	7·0

Cultivation of the mould is described in the text. In the control flasks (−P), no inorganic phosphate was detectable in the medium after 20 hr. of cultivation.

* One unit of phosphatase is defined as the amount of enzyme which can release one μ-mole of phosphorus per min. under respective assay conditions.

† −P, flasks to which no additional inorganic phosphate was added. +P, flasks to which 122 μgm. phosphorus/ml., as potassium dihydrogen phosphate, was added after 20 hr. of incubation.

that this particular repressor system will prove to be part of a general mechanism for the regulation of microbial phosphorus metabolism, although it may take such a role in those strains possessing this repressor system.

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INTESTINAL CARBOHYDRASES OF A NEW-BORN PIG

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THE activity of digestive carbohydrases of the new-born mammal differs from that of the adult animal. The development of the digestive carbohydrase system of the pig as well as the ability of the growing pig to utilize various dietary sugars have been the subject of several recent investigations[1–6]. It has been found that the lactase activity of the small intestinal mucosa is high at birth, and remains so for the first weeks of life[2,6]. It then gradually decreases, although some lactase is present in the small intestine of the adult pig too[7]. The intestinal maltase and invertase activities, to the contrary, which for many years have been thought to be due to a single enzyme, intestinal α-glucosidase[8], are weak or absent at birth and develop gradually during growth[3,6]. The amylase activity of the pancreas likewise is low at birth and increases during growth[2]. The new-born pig, therefore, is unable to utilize some dietary carbohydrates, as sucrose and starch, which are readily utilized by the adult animal[1,5,6].

Recently it has been found that the digestive carbohydrase system of the adult pig is more complicated than was believed earlier. Instead of a single intestinal α-glucosidase[8] there exist five or six different intestinal α-glucosidases[9], namely, three different maltases (maltase I–III), one of which (maltase I) also exerts all the intestinal invertase activity[10,11], a specific intestinal trehalase[12], an *iso*maltase[13] and a phenyl-α-glucosidase[13]. The two latter enzymes may, however, be identical[9,13]. Since lactase is also present[7], the adult pig has at least six different intestinal glycosidases. In addition, preparations of intestinal mucosa are known to hydrolyse β-glucosides[14]. An intestinal dextranase, distinguished from amylase, has also been found[15,16].

To define those enzymes present at birth, the carbohydrase activities of a homogenate of the small intestine of a new-born pig have been measured. The pig was slaughtered a few hours after birth, and the small intestine, which weighed 19 gm., was homogenized for 2 min. in an Ultra-Turrax homogenizer with 19 ml. of 0·01 *M* phosphate buffer, *p*H 6·0. After centrifugation in a laboratory

Table 1

	Activity of homogenate units/ml.	
	(*a*) New-born pig	(*b*) Adult pig
Invertase	0	78
Maltase I	0	55
Maltase II	13	248
Maltase III	7	66
*Iso*maltase (total)	9	30
Trehalase	0	36
Phenyl-α-glucosidase (total)	0·8	16
Lactase	104	42
Cellobiase	30	13
Gentiobiase	1·8	0·7
Phenyl-β-glucosidase	24	2·1
Amylase	26	1,800
Dextranase	0	2

Carbohydrase activities of homogenates of (*a*) the small intestine of a new-born pig, and (*b*) mucosa from the upper part of the jejunum of an adult pig. Protein contents of the homogenates (*a*) 44 mgm./ml. and 62 mgm./ml. The figures in (*a*) and (*b*) can be compared, but only approximately.

centrifuge for 5 min. the opalescent supernatant, which contains the carbohydrase activities[7], was analysed by means of methods described elsewhere[16,17]. Conditions for the carbohydrase activity determinations were such that 0·5 unit per ml. of homogenate could be detected.

The carbohydrase activities of the homogenate are seen in Table 1. For comparison, this table also includes the carbohydrase activities of a mucosal homogenate from the upper part of the jejunum of an adult pig.

The wall of the small intestine from the new-born pig was so thin that it proved impossible to scrape off the mucosa; hence, the entire small intestine was homogenized. This means, however, that the homogenate, made 1 : 1 w/v in buffer, was somewhat more dilute in mucosal protein than in the experiments with the adult pig, where only the mucosa from the intestine was homogenized. The values expressed are thus somewhat lower than would be found in a mucosal homogenate, but an approximate comparison with the adult pig values is possible.

No invertase activity could be detected in the homogenate from the new-born pig, which is in accordance with earlier findings[3,4] and also with the fact that new-born pigs cannot utilize dietary sucrose[1]. The homogenate from the adult pig had strong invertase activity (Table 1).

Maltase activity was found in the preparation from the new-born animal, although this activity was weak. The maltase activity was less than one-tenth that of the adult animal preparation (Table 1). Since it is known that the maltase activity of the ileum of adult animals is greater than that of the jejunum[16], the difference would have been still greater if the whole small intestine had been used in the experiments with the adult animal.

The maltase activity seems, however, to increase rapidly during the first phase of growth[3,5]. After two days of life pigs seem able to utilize dietary maltose[5], although they are still unable to utilize sucrose.

Heat inactivation experiments, performed as described earlier[9,17–19], indicated that the maltase activity of the preparation from the new-born pig was exerted by a mixture of maltase II (65 per cent) and maltase III (35 per cent). Apparently these enzymes appear in the small intestine of the growing pig earlier than maltase I, which hydrolyses sucrose in addition to maltose[9–11].

Neither trehalase nor *iso*maltase activity could be detected in the preparation from the new-born pig. In the small intestine of the adult pig there exist one trehalase and one specific *iso*maltase[9,11,12]. The weak *iso*maltase activity known to be exerted by maltase II and maltase III[10] was too weak to be detected under the conditions used.

The phenyl-α-glucosidase activity was less than one-tenth that of the preparation from the adult animal. This activity may very well be caused by maltase II and maltase III[10,17], and hence there is no specific phenyl-α-glucosidase[13] present in the intestine of the new-born pig.

Lactase activity, in accord with earlier reports[3,4], was greater in the preparation from the new-born animal, which is of obvious physiological importance. However, the β-glucosidase (cellobiase, gentiobiase and phenyl-β-glucosidase) activities were high although β-glucosides are not physiological nutrients for the new-born pig. The high β-glucosidase activities of this preparation suggest that these activities may be exerted by intestinal lactase (β-galactosidase) and that there exists no specific intestinal β-glucosidase. This idea is also supported by separation experiments which are in progress in our laboratory.

The phenyl-β-glucosidase activity may, however, be exerted by more than one enzyme, since the phenyl-β-glucosidase/lactase activity quotient of the preparation from the new-born pig was about 5 times that of the preparation from the adult pig, while the cellobiase/lactase and gentiobiase/lactase activity-quotients were the same in both preparations.

Amylase activity was low, compared with that of the preparation from the adult animal. Since the main source of amylase in the pig is the pancreas[14], however, no conclusions may be drawn about the ability of the new-born pig to digest starch. The pancreatic amylase activity of new-born pigs and their ability to digest starch have been studied by others[3,4].

Dextranase activity could not be detected. In contrast to amylase, this enzyme is localized to the intestinal mucosa of the adult animal[18], but its activity is quite weak.

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EFFECT OF MITOMYCIN C ON THE SYNTHESIS OF INFECTIVE VIRUS AND DEOXYRIBONUCLEIC ACID IN PSEUDORABIES VIRUS-INFECTED RABBIT KIDNEY CELLS

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THE antibiotic mitomycin *C* prevents the synthesis of deoxyribonucleic acid (DNA) without affecting the synthesis of ribonucleic acid (RNA) or protein in *Escherichia coli*.[1,2]. After infection with bacteriophages T_2, T_3, and T_5, cells treated with mitomycin *C* regain the ability to synthesize DNA, as shown by Sekiguchi and Tagaki[2]; the phage particles produced by these cells are, however, non-infective. These results are interpreted by the authors to mean that DNA synthesis proceeds in phage-infected bacterial cells through a pathway which differs from that of non-infected cells and which is resistant to the action of mitomycin *C*.

An alternative explanation of these results is that infection of the cells is followed by a massive induction of the enzymes connected with the synthesis of DNA, some of which are inhibited by mitomycin *C*. Previous experiments[3] have revealed that infection of rabbit kidney cells with pseudorabies virus causes an increase or decrease in the rate of DNA synthesis depending on the physiological state of the host cells. It was of interest, therefore, to examine the effects of mitomycin *C* using the pseudorabies virus-rabbit kidney cell system with particular emphasis on a comparison of the results obtained with rabbit kidney cells in the stationary and in the actively growing phases.

Primary monolayer cultures of rabbit kidney cells were prepared as described previously[4] and were cultivated in Petri plates in a medium composed of 96·5 per cent Earle's saline, 0·5 per cent lactalbumin hydrolysate, and 3 per cent bovine serum. Cultures were incubated at 37° in a humid atmosphere containing 5 per cent carbon dioxide. Virus titres were measured by the plaque method. The procedures used for the determination of RNA, DNA, and protein and for the incorporation of labelled nucleosides were the same as reported previously[3]. The number of virus particles was determined by electron microscopy. Virus preparations were mixed with a known number of polystyrene latex particles, the mixtures were sprayed on electron microscope screens, and counts were made from electron micrographs[5,6].

The action of mitomycin *C* on rabbit kidney cells is similar to its action on bacterial cells. The addition of 5 μgm. of mitomycin *C* per ml. to rabbit kidney cells results in an immediate reduction in the ability of these cells to incorporate thymidine into their DNA. After 4 hr. of incubation with the antibiotic the cells incorporate only 2–3 per cent as much thymidine as the untreated controls. The same concentration of mitomycin *C* has comparatively little effect on the incorporation of uridine into RNA: even after 24 hr. of incubation with mitomycin *C* this incorporation is reduced by only approximately 25 per cent.

The synthesis of DNA in pseudorabies virus-infected cells treated with mitomycin *C* is highly dependent on the physiological state of the cells at the time of addition of mitomycin *C*. (Previous experiments have demonstrated that cells in the stationary phase of growth are stimulated by pseudorabies virus infection to incorporate up to twenty-fold more thymidine than non-infected controls; infection of actively growing cells results, on the other hand, in a reduction in their capacity to incorporate thymidine[3].) Nine-day-old stationary phase cultures, as well as 4-day-old actively growing cultures, were incubated with 5 μgm. of mitomycin *C* per ml. for 18 hr. Part of the cultures was infected with an adsorbed multiplicity of 5 and incubation was continued in the presence of mitomycin *C*. Cultures which had not been exposed to the antibiotic (infected and non-infected) were used as controls. At various times after infection $3{\cdot}3 \times 10^4$ c.p.m. of thymidine-2-^{14}C (specific activity $8{\cdot}7 \times 10^3$ c.p.m./μgm. of thymidine) were added to the cultures and incorporation was allowed to proceed for 1 hr. The specific activity of the DNA was then determined. Fig. 1 summarizes the results of this experiment.

Nine-day-old cultures treated with mitomycin *C* regain the ability to incorporate thymidine after infection and for the first 4 hours incorporate thymidine at a rate similar to that of the untreated controls; after 4 hours there is a sharp decrease in the rate of this uptake. Four-day-old cultures treated with mitomycin *C*, however, remain unable to incorporate thymidine after infection. Thus, the action of mitomycin *C* on DNA synthesis is reversed by infection with pseudorabies virus only in cells in which the synthesis of DNA is thereby stimulated. These results suggest that this reversal may be a reflexion of the induction in these cells of enzymes (some of which are sensitive to mitomycin *C*) con-

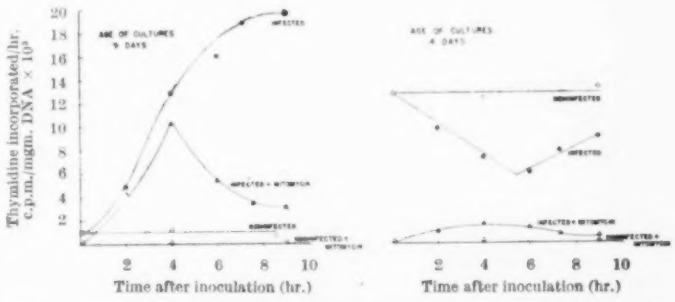

Fig. 1. The effect of virus infection on stationary phase and actively growing rabbit kidney cells, after treatment with mitomycin *C*, on their ability to incorporate thymidine-2-^{14}C

nected with the synthesis of DNA. Furthermore, the initial rapid increase in the ability of 9-day-old infected cultures treated with mitomycin *C* to incorporate thymidine, which is followed by a loss of this ability, seems to be due to the induction of these enzymes at a rate which, for the first 4 hr. after infection, exceeds the rate of their inhibition by mitomycin *C*. Thus, under certain conditions, infection with pseudorabies virus overcomes the block of the synthesis of DNA caused by mitomycin *C*, as infection with bacteriophage does in *E. coli* treated with mitomycin *C*. In the case of pseudorabies virus-infected rabbit kidney cells, however, this reversal is readily explainable in terms of a massive induction of enzymes connected with the synthesis of DNA.

Despite the ability of 9-day-old cultures treated with mitomycin *C* to synthesize DNA after infection with pseudorabies virus, the yield of infective virus produced by these cells is low. Non-infective virus particles are, however, formed by cells treated with mitomycin *C*, as shown in the next experiment. Cells were incubated for 4 hr. with 5 μgm. of mitomycin *C* per ml. They were infected and incubated for an additional 24 hr. in the presence of mitomycin *C*. (Cultures treated identically in the absence of mitomycin *C* were used as controls.) The fluids were harvested, the cellular debris was removed by centrifugation, and the clear supernatant fluids were subjected to 2 alternate cycles of high-speed (73,300 *g* for 60 min.) and low-speed (1,700 *g* for 20 min.) centrifugations. The preparations, suspended in one-tenth the initial volume, were assayed for infective virus (measured by plaque-forming units) and for physical particles (determined by electron microscopy). Table 1 shows the ratio of plaque-forming units to physical particles in these preparations. Although the number of plaque-forming units in the sample obtained from the cells treated with mitomycin *C* is more than 700 times lower than that of the control sample, the number of physical particles in both samples differs by only a factor of 3·2.

Table 1. Effect of Mitomycin *C* (MC) on the Ability of Rabbit Kidney Cells to Produce Infective and Non-infective Virus Particles

	MC-treated	Untreated	MC-treated / Untreated
Virus titre, PFU/ml.	$1·5 \times 10^7$	$1·1 \times 10^{10}$	1/740
Virus particles/ml.	$1·8 \times 10^{11}$	$5·5 \times 10^{11}$	1/3·2

PFU, plaque-forming units.

The next experiment shows that the non-infective particles produced by cells treated with mitomycin *C* can induce in the cells to which they are adsorbed the characteristic cytopathic changes (intranuclear inclusions and syncytia) which result from infection of rabbit kidney cells with normal infective virus particles. Cultures were incubated with 5 μgm. of mitomycin *C* per ml. for 4 hr. They were infected and incubated for an additional 24 hr. in the presence of mitomycin *C*. The fluids of these cultures, as well as of control cultures not treated with mitomycin *C*, were harvested and submitted to low-speed centrifugation to remove the cellular debris. One ml. of different dilutions of these fluids was added to rabbit kidney cultures (containing 4×10^6 cells ± 10 per cent per culture). After an adsorption period of 1 hour the cultures were washed to remove unadsorbed virus and were incubated in 5 ml. of medium for 3 hr. at 37°. The cells were then fixed with Bouin fluid, stained with hæmatoxylin, and the percentage of cells containing inclusion bodies determined. (Inclusion bodies start to appear in the nucleus 3 hr. after inoculation and increase in number with time. Previous experiments (unpublished) have shown that between 3 and 6 hr. after infection the number of inclusions is proportional to the multiplicity of infection. Since the latent period of pseudorabies virus in rabbit kidney cells is approximately 4–5 hr., the experiment was ended at 4 hr. to avoid the problem of recycling.) Assuming a Poisson distribution, the number of inclusion-forming units, which give rise to an inclusion during the first 4 hr. of incubation, was calculated from the number of intranuclear inclusions obtained with various concentrations of the samples. Table 2 shows the number of plaque-forming units and inclusion-forming units in mitomycin *C*-treated and untreated samples. Although the number of plaque-forming units produced by the treated cultures is 220 times lower than that of the untreated controls, the number of inclusion-forming units in both samples differs by only a factor of 3·4. The ratio of the number of inclusion-forming units produced by treated and untreated cells is comparable to the ratio of the number of viral particles in the two samples as determined by electron microscopy. Moreover, syncytia are formed in cultures infected with mitomycin *C* virus with a multiplicity of plaque-forming units per cell too low to induce these cytopathic changes with control virus. We conclude from these experiments that the non-infective virus particles which are formed in cells treated with mitomycin *C* are able to induce in rabbit kidney cells to which they are adsorbed the characteristic changes observed after inoculation of these cells with infective pseudorabies virus.

Table 2. Number of Plaque-forming Units (PFU) and Inclusion-forming Units (IFU) produced by MC-treated and Untreated Rabbit Kidney Cells

	MC-treated	Untreated	MC-treated / Untreated
PFU/ml.	1×10^7	$2·2 \times 10^9$	1/220
IFU/ml.	$8·8 \times 10^7$	3×10^8	1/3·4

The action of mitomycin *C* on the rabbit kidney cell–pseudorabies virus system is thus similar to that previously reported for the *E. coli*–bacteriophage system. Our findings may be summarized as follows: the inhibition of DNA synthesis in cells treated with mitomycin *C* is overcome under certain conditions by infection with pseudorabies virus, probably as a result of an induction by the virus in the infected cells of enzymes connected with the DNA synthesizing mechanism; the DNA formed under these conditions does not seem to be functional and the virus particles formed are non-infective.

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LETTERS TO THE EDITORS

GEOPHYSICS

A Preliminary Model for the Variations of Upper Air Densities

SATELLITE observations have shown a significant variability of the density of the upper air above a height of 200 km. During the period 1957–60, several major effects must be distinguished, in addition to dependence on altitude. The construction of general representative atmospheric models is therefore extremely difficult, as has been found by several authors[1]. Hence it seems to be more useful to give a model for the variability, from which the density of the air can be calculated for special cases. Three influences seem to be predominant[2]: (1) The solar W-effect produced by the variable short wave-length solar ultra-violet radiation. This is demonstrated by a strong correlation with the sunspot number[3] or with the solar radio emission in the decimetre wave-length region[4]. (2) The day–night effect, the amplitude of which increases strongly with height[5]. (3) The annual effect. This effect shows a pronounced annual and a semi-annual period[2]. It is demonstrated by the fact that for different satellites the day–night variation is not constant in phase and amplitude if it is normalized for a constant solar W-effect[6]. This third effect is probably caused by the interaction with interplanetary plasma, the density of which varies along the Earth's orbit perhaps due to an interstellar wind[7].

Let F be the intensity of the solar ultra-violet radiation at 10 cm. wave-length; θ be the local time; a be the date in the year, $\rho_{max.}(\theta)$, $\rho_{min.}(\theta)$ be the diurnal and annual maximum density. Then the three influences above can be expressed by the following functions:

$$f(\theta) = \log \frac{\rho_{max.}(\theta)}{\rho(\theta)},\ g(a) = \log \frac{\rho_{max.}(a)}{\rho(a)},$$
$$i(F,h) = \log \frac{\rho(220,\ h)}{\rho(F,h)} \qquad (1)$$

$\rho(220)$ means the air density when the intensity of 10-cm. wave-length solar radiation is $F = 220 \times 10^{-22}$ W./m.²c./s. The dependence on altitude of $f(\theta)$ and $g(a)$ may be expressed by the function $\theta(h)$ and $a(h)$. Then the air density $\rho(h)$ can be calculated as a good first approximation from:

$$\log \rho(h) = \log \rho_{stand.} - [f(\theta)\theta(h) + g(a)a(h) + i\,(F,h)] \qquad (2)$$

$\rho_{stand.}$ is given in Table 1, while the other functions are shown in Figs. 1 and 2. The function $\rho_{stand.}$ was extended up to 1,500 km. altitude by the observed acceleration of *Echo I* (1960_{ι_2}) (ref. 8). The plausible physical product of the combinations $f(\theta).\theta(h)$ and $g(a).a(h)$ has been proved by the observations of different satellites, which agree well with this assumption.

Table 1

Height (km.)	Density (gm./cm.³)	Height (km.)	Density (gm./cm.³)
180	$5{\cdot}9 \times 10^{-13}$	500	$4{\cdot}7 \times 10^{-15}$
220	$3{\cdot}0$	600	$1{\cdot}8$
260	$1{\cdot}2$	700	$7{\cdot}1 \times 10^{-16}$
300	$5{\cdot}9 \times 10^{-14}$	1,000	$7{\cdot}8 \times 10^{-17}$
400	$1{\cdot}5$	1,500	$8{\cdot}0 \times 10^{-18}$

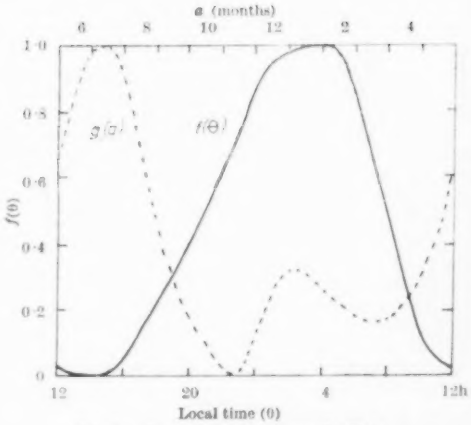

Fig. 1. Diurnal and the annual effects

Further, some minor influences exist. The magnetic activity enhances the air density by about 5 per cent if the planetary magnetic index A_P increases from 10 to 20, etc. Greater variations are only observed during magnetic storms, when the density may increase by about 30 per cent over 200 km. in height[9]. Finally, a weak influence of latitude and seasons has been found from observations of some of the *Discoverer* satellites, the orbits of which extended to polar latitudes (unpublished work). At an altitude of 200 km., the density of the air is about 10 per cent smaller in polar latitudes than in lower latitudes

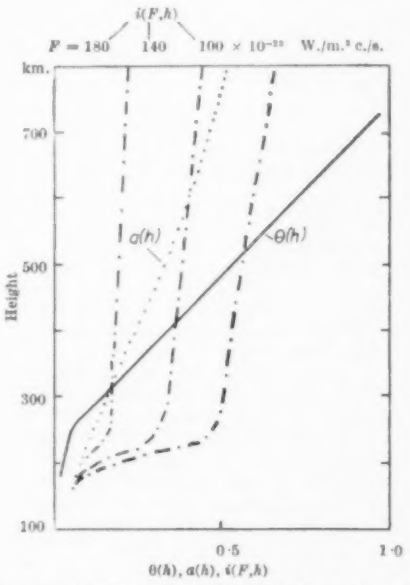

Fig. 2. Dependence on altitude of the W-effect, the diurnal and the annual effect

during the winter. On the other hand, a density gradient of about 15 per cent exists from the equator to the pole over the summer hemisphere.

The proposed model covers only the variations of density with a time-scale greater than one day. During strong solar flares the density of the upper atmosphere may increase considerably for a short time. The function $g(a)$ in Fig. 2 relates to the time November 1957–July 1960. Apparently in the yearly variation an annual and a semi-annual period are superposed[7]. The first has been already found in the variations of the F-layer[10] and recently also in the exospheric electron-density after whistler observations[11]. The semi-annual effect has been recently found also for the E-layer[12]. Because the annual and semi-annual effects are probably caused by the influence of the inter-planetary plasma on the upper atmosphere, its amplitude may vary with the solar cycle. This is shown by the last observations up to February 1961, when the sunspot activity was already weak. During this time the annual and the semi-annual effect was found to be considerably lower than that during the strong sunspot maximum of 1957–58. Further, some minor irregularities of the air drag seem to remain, perhaps due to inhomogeneities of the interplanetary matter. In summary, the fluctuations of the density (and temperature) of the upper atmosphere are so complex that any model may differ considerably sometimes from the real values.

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Palæomagnetic Evidence relevant to a Change in the Earth's Radius

Cox and Doell[1], applying a suggestion of Egyed[2] to test the reality of the expansion of the Earth through geological time, have calculated the radius of the Earth implied by comparison of Permian palæomagnetic measurements in the Maymecha–Kotuy region of Siberia and localities in western Europe, and find that although the standard deviation of the individual results is very wide indeed, the average of the computed radii of the Earth is close to the present radius. From this they conclude that the substantial post-Palæozoic expansion of the globe deduced by me on tectonic grounds is unlikely.

Cox and Doell state that "in the expansion of the Earth envisaged by Carey, Heezen and Egyed, the continents do not increase in area; hence, the distance between any two points on a stable part of one continent remains constant". When applied to the geotectonic synthesis presented by me in the paper quoted by them[3], this statement is certainly invalid. In each of the figures for the Asian continent in my paper I show the Asian block as composite, and elongation since the Palæozoic is explicitly shown on Fig. 9, and implicitly on Figs. 10, 39*b* and 39*d*. The Ob rhombochasm is discussed on pp. 203–204 and rhombochasm is defined on p. 192 as "a parallel-sided gap in the sialic crust occupied by simatic crust and interpreted as a dilatation". The extensions specified above fall between the sampling areas used by the authors and involve an extension of some 900 km. This is of the right order for the angular distance measured between these districts to remain unchanged if the surface area of the Earth had increased some 45 per cent since the Palæozoic.

The magnetic data presented by Cox and Doell are therefore what they should be if the tectonic synthesis presented by me is correct.

It would be possible to apply Egyed's method to places on the Earth which would provide a decisive test. This may be done, either by comparing localities which do satisfy the conditions stated by Cox and Doell, or alternatively by selecting localities on separated blocks such as Africa and South America or Australia and Siberia and testing whether the surface distance between them on the Palæozoic reconstruction, taken with their ancient latitudes implied by the palæomagnetic data, correspond to an Earth of the present radius or of a different radius. I examined the data superficially from this point of view in 1958, but concluded that the uncertainty within the magnetic data then available was too wide to give a useful result.

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It is important to note that if, during an expansion of the Earth, each point on the surface were to move radially outward, then all sampling areas would have the same relative geographical co-ordinates before and after expansion. Palæomagnetic results could not be used to detect an expansion of this type. However, an alternative model of expansion is that in which most or all of the increase in area is reflected by an increase in the area of the ocean basins. We considered Prof. Carey's model of Earth expansion to be of this general type, since he concludes[3] that the Atlantic, Indian and Pacific Ocean basins formed by dilatation attendant on expansion. If the ocean basins formed in this way, the method we used would show an increase in the Earth's radius, even if the continents had also grown a lesser amount.

The crucial point raised by Prof. Carey concerns a proposed separation of the two sampling areas used in our calculation. The 900-km. dilatation suggested by him would certainly mask an increase of 1,100 km. in the Earth's radius, provided the elongation took place along the meridian connecting the two sampling areas and the ancient pole. Implicit in Prof. Carey's reconstruction of the Eurasian landmass[2] there is, indeed, a 900-km. displacement of the Siberian sampling area with respect to Europe; its direction, however, is not along the ancient meridian, but rather at an angle of some 50° to it. The component of elongation in the ancient meridional direction in Prof. Carey's reconstruction is less than

600 km., not enough to mask an expansion of 1,100 km. Thus Prof. Carey's detailed model is not supported by the European and Siberian palæomagnetic results.

We join Prof. Carey in looking forward to future applications of this method. As he suggests, the method might also be applied to data from different continents after reassembling them into a single land-mass, assuming continental drift has occurred. However, such a calculation of the ancient radius would introduce additional uncertainties concerning the particular reconstruction used. We consider it preferable to use results from individual land-masses to test for expansion, and then proceed to compare results between continents as a test for continental drift.

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PHYSICS

Shock-excited Dark Discharge

The existence of the so-called dark discharge region has been known from the earliest days of discharge in gases. Here, continuous current densities of the order of μamp./cm.² involve no luminous effects and are attributed to the by-products of cosmic ray or other sources of weak ionization in the discharge space; as the current density is made to increase, the well-known 'glow' and 'arc' regions are successively established.

It is, however, possible to obtain current densities of about 5 amp./cm.² for the 'dark' discharge condition when excitation is induced by the partial discharge of a small condenser bank in a somewhat critical pressure-range. We have found that in hydrogen, at pressures not exceeding 0·1 mm. mercury and using plane brass electrodes of diameter 2¼ in., spacing 5¼ in., not heat-treated or specially cleaned in any way, shock excitation of the gas yields a dark discharge (that is, with no apparent visible glow) involving peak currents of some 400 amp. lasting for a time of the order of 1 μsec. The main features of the discharge can be summarized as follows:

(1) Although the upper limit of pressure appears to be critical around 0·1 mm. mercury, it is possible to excite the dark condition at lower pressures, if the potential is increased.

(2) Current densities range from about 2·5 to 15 amp./cm.², but repeatability was generally poor due to the presence of fatigue factors—these could be annulled by working at higher excitation voltages.

(3) The range of current values correspond with that expected from the approximate charge transferred, $2{\cdot}5 \times 10^{-4}$ coulomb as a minimum; values as high as 10×10^{-4} coulomb yielded little variation in peak current, but produced a longer discharge time.

(4) Above the critical pressure, an increase of pressure by a few per cent gave the standard glow in place of the 'dark' discharge at the higher voltages; however, even at this somewhat increased pressure, once the glow condition has been established, it is possible to induce a 'dark' discharge at about one-third of the glow voltage.

(5) There is no 'follow through' for this type of discharge—a certain amount of energy is drained away and the factors responsible for building up the more highly conducting condition disperse rapidly.

(6) The initiation of the 'dark' condition appears to be connected with the properties of the surfaces taking part in and exposed to the gas—'conditioning' by a succession of such discharges involving higher and higher energy dissipation makes it extremely difficult to reproduce the discharge under the conditions available to us.

(7) It was very occasionally possible to record a 'dark' discharge in air at a pressure of 0·01 mm.

The use of 'slow' mercury switching in these experiments is likely to introduce a variable and somewhat high-resistance path in the early conducting stages; it may well be that the 'build up' to the dark condition is a function of the manner and amount of the energy loss at the switch; in many cases the tube 'build up' is rapid enough to 'blow' one of the four switches (in parallel) in the bank.

An interesting parallel to the behaviour described in this communication followed some work reported in an early communication[1] on the scintillation discharge in neon. Here, one of the authors (L. J.) met the 'silent' discharge condition in neon and other gases—krypton, hydrogen, carbon dioxide, nitrogen—in the pressure range 1–10 mm., and where, in fact, the ratio of electrode separation to mean free path was of the same order as in the present experiments. Whereas current densities of some 100 amp./cm.² were then recorded for the 'scintillation' condition, only some 5 amp./cm.² was noted for the 'silent' discharge. The development of the 'scintillation' in hydrogen in the present experiments involved current densities of the order of 250 amp./cm.² and generally followed a pre-breakdown glow stage; there appears to be no 'pinch' effect present. Some factors on which the heavy current condition depends—for example, surface properties of the electrodes, polarity of the discharge, ratio of electrode areas—are expected to affect the dark discharge condition in much the same way.

We are indebted to the Department of Scientific and Industrial Research for a grant towards this work.

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Spiral Etch-Pits of Ice Crystals

Though the correspondence of etch-pits to dislocation has been investigated by many workers for various crystals, there have not been many direct observations of spiral structure of the etch-pit, which may be considered to be related to the screw dislocation. Spiral etch-pits on sodium chloride[1], on germanium[2,3], on silicon[4], on α brass[5], and on

antimony[6] have been reported. The observed step-heights of etch-terraces are in the range 500 Å.–40,000 Å. Since these values of step-heights are large in comparison with a Burgers vector, the relation between these spiral etch-pits and the screw-dislocation is not as definite as that between the spiral growth pattern of crystal and the screw-dislocation.

Higuchi[7] succeeded in producing large etch-pits on the surface of ice by the use of plastic replica film. The size of these large etch-pits is about 0·5 mm., and the crystallographic basal plane appears in the etch-pits, when the surface of the ice is nearly perpendicular to the optical axis. By electron-microscope observations, it was found that minute hexagonal etch-pits are formed on the basal plane of these etch-pits by the evaporation process, and that some of them showed the spiral structure.

I used lake ice and on the ice surface nearly perpendicular to the *c*-axis, I produced large hexagonal etch-pits with basal planes by Higuchi's method. Then, the positive plastic replica of these basal planes was made with 'Formvar'[8], the concentration being 0·5 per cent. After shadowing with chromium vapour at an angle of 12°, this plastic replica was observed under an electron-microscope.

Figs. 1 and 3 show electron-photomicrographs of the minute etch-pits produced on the basal plane. Fig. 2 is a sketch of the stepped structure shown in Fig. 1. As seen in these figures, the stepped structure

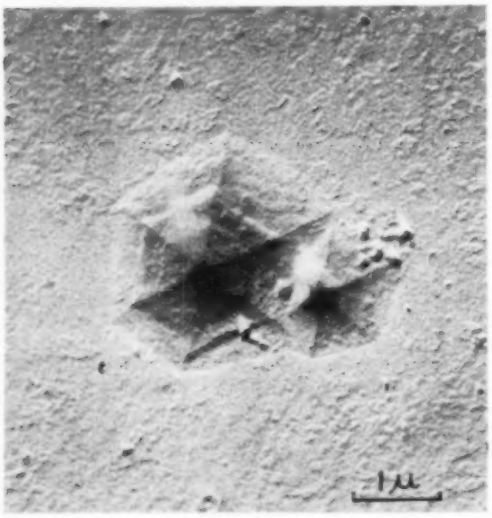

Fig. 1. Spiral etch-pits of ice crystal. (× 13,300)

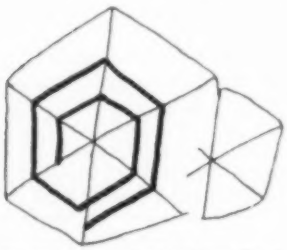

Fig. 2. Sketch of etch-pit from Fig. 1

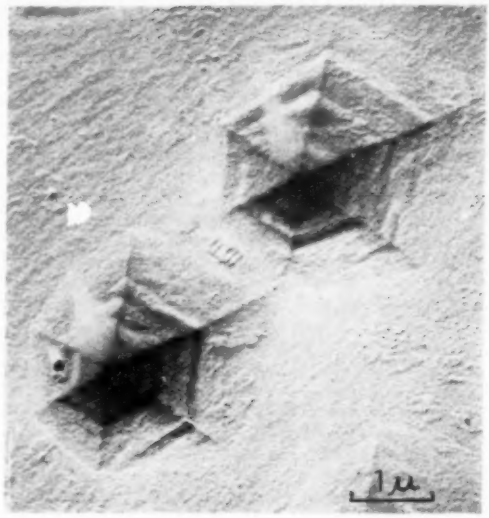

Fig. 3. Spiral etch-pits of ice crystal. (× 12,500)

shows the spiral pattern. From many electron photomicrographs, the mean height of steps was estimated to be 200 Å.–2,000 Å. These values are nearly of the same order of magnitude as reported for the stepped structure of a growing ice-surface[9]; that is, 500 Å.

This work was carried out in 1958 at the suggestion of Dr. K. Higuchi, and I thank him. I am grateful also to Prof. U. Nakaya, Dr. D. Kuroiwa and Dr. T. Mitui for their kind discussions.

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Discrimination between α-Tracks and γ-Background in Ilford Nuclear Emulsions

We have attempted to improve the discrimination between α-tracks and γ-background in Ilford 50μ nuclear emulsions by utilizing the Herschel effect[1]. The Ilford emulsions being sensitive to infra-red, direct application of the Herschel effect resulted only in a blackening of the emulsions. Therefore a desensitizer was necessary; phenosafranine was chosen[2]. The emulsions were treated in the following way:

(1) Superficial irradiation with α-particles from a uranium-233 source.

(2) γ-Irradiation from a 17·5-MeVp betatron (doses varying from 2 r. up to 2,000 r.).

(3) Bathing in an aqueous solution of phenosafranine (for concentration see below); 1 hr. was necessary to allow the solution to penetrate into the emulsion.

(4) Rinsing with distilled water and drying in a slow air current.

(5) Infra-red irradiation : the light of a Philips infra-red lamp (220 V., 250 W., *E* 27, 13352 *E*/479), the filament of which was at a distance of 15 cm. from the emulsion, was passed through Schott filters *RG* 10 and *RG* 7. The filters must be placed with their esculine film side towards the lamp[3]. During the irradiation, the emulsion remained in a copper box, cooled by running water and two electric fans. An aspirator produced a cold-air current in the box. The irradiation time varied from 2 to 80 min.

(6) Immediately afterwards the emulsions were treated by temperature development (20 min. at 2° C., 15 min. at 22° C.) in a developer of the following composition :

Na_2SO_3, anhydrous	15 gm.	per litre of solution
Glycin (Johnson)	10 gm.	
Na_2CO_3, crystalline	23 gm.	
Ethyl alcohol, 94 per cent	10 c.c.	
Johnson 142	10 c.c.	

Then the emulsions were fixed in the following solution :

$Na_2S_2O_3$, crystalline	400 gm.	per litre of water
Na_2SO_3, anhydrous	12·5 gm.	
CH_3COOH 10, per cent	10 c.c.	

The emulsions were immersed in a fixing-bath at half the given concentration for 30 min., then in a fixing bath for 90 min. at full concentration, then again for 30 min. in a bath at half the concentration.

(7) Finally, the emulsions were rinsed in running water until all traces of colouring matter had disappeared ; and then they were dried.

This procedure gave the following results:

Emulsion *G5* showed a clarification after 13 min. of infra-red irradiation and a bath in phenosafranine at a concentration of 10^{-2} gm./l., with the filter *RG* 10 + *RG* 7. Discrimination improved. Higher concentrations of phenosafranine increased the clarification, but the α-tracks showed many gaps when irradiated for more than 13 min. with infra-red.

Emulsions *L4* and *K5* showed a clarification and an improvement of discrimination after a bath in phenosafranine at a concentration of 0·25 gm./litre and after 13 and 30 min. of infra-red irradiation with *RG* 10 + *RG* 7.

With the *RG* 7 filter alone, we obtained a very noticeable clarification in all types except *C2* ; but in each of the other types (*K0*, *K5*, *L4*, *G5*) the α-tracks showed many gaps, even after 2 min. of infra-red irradiation.

In emulsions *C2* and *K0*, we could not improve the discrimination between α-tracks and γ-background.

A bath in phenosafranine alone was found to give a slight clarification, without impairing the quality of the α-tracks.

Another desensitizer, pinacryptol yellow, was tried, but gave no results whatever.

In Table 1, results are given for emulsion *L4* ; *A* represents number of background grains per cm.³ of dry developed emulsion ; *B* represents number of gaps in the α-tracks per 100 blobs or grains in the track.

Table 1

Duration of infra-red irradiation	0	2m. 24s.	5m. 45s.	13m. 49s.	33m. 11s.
A	171×10^3	166×10^3	154×10^3	134×10^3	111×10^3
B	36·6	43·1	48·2	51·5	57·6

With G_5 and K_5 analogous results were obtained.

This work was part of the research programme of the Interuniversitair Instituut voor Kernwetenschappen-Belgium. We thank Prof. J. L. Verhaeghe, C. Beets and J. Fournaux for their interest in this work. We are also indebted to Prof. P. M. Van Vaerenbergh and Dr. J. Allewaert for the gamma irradiations.

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Radioactivation Analysis of Oxygen in Silicon by Irradiation with α-Particles in a Cyclotron

Although the determination of a trace of oxygen in transistor-grade silicon is very important, it cannot be done reliably by a chemical or by a neutron activation method. Radioactivation analysis using $^{16}O(t,n)^{18}F$, $^{16}O(\gamma,n)^{15}O$ and $^{17}O(d,n)^{18}F$ reactions were tried[1,2], but were far from satisfactory. Use of tritium in an atomic reactor resulted in low precision and sensitivity, owing to its short range and the inevitable presence of oxygen in lithium. Chemical separation of oxygen-15 is impractical because of its short life, and radioactivation of oxygen-17 is less advantageous because of its low abundance.

We have made use of the $^{16}O(\alpha,pn)^{18}F$ reaction for this purpose and succeeded in determining as small an amount of oxygen as 0·3 p.p.m. The excitation function for this reaction was determined by two of us[3]. A plate of silicon (30 mm. × 17 mm. × 1 mm., 1·2 gm.) was placed on a water-cooled holder with the aid of a spring washer for good contact, and irradiated with 40-MeV. α-particles in a cyclotron (5 μamp., 15 min.). Too high a flux and a poor contact caused slight fusion on the surface of the sample. The surface of the irradiated silicon was washed with dilute hydrofluoric acid containing a small amount of nitric acid to remove the surface contamination and pulverized in an iron mortar. The product was added in small portions to fused potassium hydroxide (25 gm.) containing sodium fluoride (10 mgm.) and disodium hydrogen phosphate (5 mgm.) as carrier. Sodium nitrate (0·5 gm.) was then added to convert radioactive phosphorus produced by $^{28}Si(\alpha,p)^{32}P$ and $^{30}Si(\alpha,pn)^{32}P$ reactions into phosphate, which served as an internal monitor for the flux of the α-particle beam. The cake was dissolved in sulphuric acid (200 ml.) and the fluoride distilled at 150–160° C., the distillate being caught by aqueous ammonia. The fluoride was precipitated as calcium fluoride together with calcium carbonate, filtered off, washed, dried and radioactivity measured. The time required for the separation was about 2 hr. and the overall recovery of fluoride was about 80 per cent.

The annihilation radiation was measured with a sodium iodide (1·5 in. dia. × 1 in. high and 1·75 in. dia. × 2 in. high) scintillation counter of a known efficiency, with and without a coincidence device.

The counting-rate was measured every hour for 10 hr. together with the γ-ray spectrum, which consisted only of the annihilation peak at 0·51 MeV. The decay curve agreed with that of fluorine-18. The oxygen content was calculated from the disintegration-rate of fluorine-18 by the absolute method, the contribution of $^{16}O(\alpha,p3n)^{18}F$ and $^{17}O(\alpha,p2n)^{18}F$ reactions being negligible under our conditions.

A raw silicon contained 4 p.p.m. oxygen, while a transistor-grade silicon had 0·3 p.p.m. By this method 10^{-2} p.p.m. oxygen can be determined. This method appears to be the most sensitive method for the determination of oxygen and is useful for the analysis of a solid sample having a high melting point and a low vapour pressure. The recoil effect, the evaporation of fluorine during irradiation and other details will be reported elsewhere.

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GEOLOGY

Analysis of a Supposed Clay Fulgurite from Ontario

The existence of 'clay fulgurites' from Kingston, Ontario, was reported recently by Hawkins[1]. These were described as "partially fused ellipsoids" resulting from lightning striking clay sediments. The report was of considerable interest to us because it suggests that lightning may be responsible for the formation of tektites. At our request, Dr. Hawkins kindly sent us a sample of this material. The composition is as follows:

SiO_2	29·69
Al_2O_3	12·45
Fe_2O_3	30·97
FeO	1·63
CaO	0·47
MgO	1·72
H_2O	15·50
MnO	0·31
TiO_2	0·21
Na_2O	0·44
K_2O	1·84
Organic matter	4·18
	99·41

The specimen analysed was an irregular lump 3 cm. long with a yellowish-brown colour and streak, earthy lustre, and hardness of about 1 (Mohs). Portions of the specimen were covered with a shiny brown coating which was soluble in acetone and presumed to be organic (Fig. 1). In the analysis total water was determined by the Penfield tube method and organic matter by difference between loss on ignition and total water. The chemical analysis indicates that the specimen may be mostly a hydrated iron aluminium silicate or oxide. An X-ray powder diffraction pattern showed the specimen

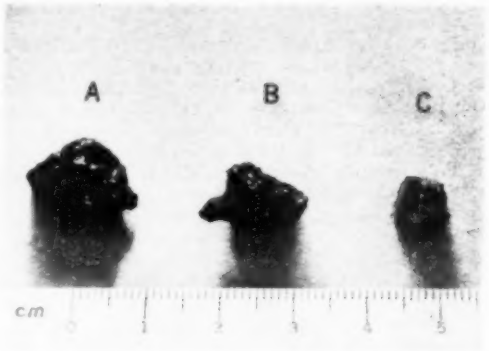

Fig. 1. Portions of the specimen marked *A* and *B* are untreated, showing their shiny coating of organic matter. The portion marked *C* was treated by immersion in acetone, exposing its dull surface

to contain some quartz, kaolinite, and additional material as yet unidentified. Petrographic examination disclosed no lechatelierite or glass. This specimen has no resemblance to any known fulgarite or tektite in composition. Therefore it appears to have no relation to the origin of tektites.

Thanks are due to E. C. T. Chao of the U.S. Geological Survey for furnishing X-ray data and to J. I. Dinnin, also of the U.S. Geological Survey, for determination of the alkalis.

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Karroo Igneous Activity and Tectonics in south-east Southern Rhodesia

During the period 1956–60, members of the University of Leeds Research Institute of African Geology, under the direction of Prof. W. Q. Kennedy, have been investigating Karroo (early Mesozoic) igneous activity and tectonics in the south-east of Southern Rhodesia. Field-work has now been completed and it is intended in due course to publish the results in detail. In the meantime, we present here some aspects of the geology of the area which may be of general interest.

The Basement Complex underlying the area investigated (see Fig. 1) consists of highly folded gneissose rocks and represents part of the east-north-east trending Limpopo orogenic belt (*circa* 2,000 m.y.)[1], which separates the stable blocks of Southern Rhodesia and the Transvaal.

Warping and fracturing of the Dominion Reef, Loskop and Waterberg systems in the northern Transvaal indicate that the Limpopo belt continued to mark an important tectonic line at a later period (? late-Precambrian).

In the Karroo period, a relatively thick succession of sandstones, mudstones and shales, with some coal, was deposited in the vicinity of the present-day

(*Continued on page* 77)

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Supplement to NATURE

No. 4770 APRIL 1, 1961 Vol. 190

THE EXPANDING POPULATION

The Population Explosion and Christian Responsibility

By Dr. Richard M. Fagley. Pp. xii + 260. (London: Oxford University Press; New York: Oxford University Press, Inc., 1960.) 28*s.* net.

DR. FAGLEY has written a useful and timely book which, it must be hoped, will be read by many thoughtful citizens. As the title indicates, it is directed to Christians, in the first place, with the purpose of arousing them to think seriously on the dangers inherent in the "Population Explosion", a picturesque name for the rapid expansion of the population of the world. In this it should be successful, for the writing is lively and clear, while the Christian background of the author is evident throughout. No one should dismiss it, however, as one more appeal to uninformed sentiment or theological dogma. The demographic facts are clearly set out with references to sources, and the probable consequences for the future of mankind are stated calmly and objectively. So far as I can judge, the author has put the case with due regard to scientific accuracy, and, when more than one estimate of the future development of populations is available, has chosen the least alarming among those offered by competent authorities. The Christian bias in this section of the book makes a welcome appearance at the conclusion of the factual and impersonal exposition, when the author reminds us of the human values which are in danger. "The main issue is the family caught in the ferment and upheaval of social change, bewildered, frightened, subject to disruptive forces, tending to lose its spiritual and social moorings. Here is found the most fundamental cost of the new pressures of population."

The book surveys various possibilities of mitigating the situation. A short discussion of the potentialities of improved methods of food production tends to the conclusion that they are unlikely to be adequate to do more than defer the catastrophe. The most controversial section of the book deals with birth-control, its methods, its sociological bearings and its ethical problems. In this, of course, we come squarely up against religion, and, to many readers, the author's summary of the different attitudes and teachings of the chief religions of the world will be most informative. Naturally by far the greatest space is devoted to Christianity, and, in spite of a few unimportant historical slips, the account of the chief traditions in the Church on the subject of birth-control is clear and fair. The chapter on the Roman Catholic doctrine is pre-eminently objective and sympathetic, which is no small achievement by a writer who cordially disagrees with it. His opinion, supported by documents, is that the rest of Christendom and its groups, with various velocities and degrees of clarity of thought, are moving towards an agreement on the subject of birth-control and the formulation of a moral theology for the guidance of their members. The present writer cannot forbear to point out that the Anglican Church, according to Dr. Fagley, has advanced further than any other in its thinking on this matter. But this is of small importance. The really important message of the book is that the time is short. We cannot wait for a century of discussion. The time to think and act is now, and Christians have a responsibility to reach an informed judgment and to persuade the politicians to lift their eyes to the future and consider the prospects of the human race.

W. R. MATTHEWS

A. V. HILL

The Ethical Dilemma of Science and Other Writings

By Prof. A. V. Hill. Pp. xiii + 395. (New York: Rockefeller Institute Press; London: Oxford University Press, 1960.) 7·50 dollars; 52*s.* net.

THERE may be some, perhaps, who will expect the short title of Prof. Hill's book, as it appears on the cover, to indicate the general tone and purpose of its contents as a whole. They should be neither disappointed nor relieved to find that it provides, in fact, a meal of many different courses. "The ethical dilemma of science" must, indeed, for the author, as for any man of science concerned for the future of civilization, be a subject seldom absent from his thoughts. In this widely ranging collection of his writings, however, it figures primarily as the title of the noble presidential address which he gave to the British Association at its Belfast meeting in 1952; and it is then applied, more inclusively, only to the first chapter, consisting of various addresses dealing with the aims and prospects of science.

The internal title-page of the book adds "and other writings"; and such an extension is certainly required to give any inkling of the rich variety characterizing the products of his wide interests and agile brain which Prof. Hill has here collected. They range, indeed, from deeply considered and eloquently presented addresses, lectures and speeches, some of them in Parliament during his war-time membership, to typically generous and affectionate memorials and tributes, to men who have been his heroes, comrades and friends. They include full-blooded denunciations of social and political tyranny, and championship of its victims; claims for what science could do, criticism of its neglect and misuse, from first-hand experience in two world wars; and advocacy of what it could yet do for the Commonwealth, and especially for India's problems, based in the latter case on knowledge gained directly on a special mission.

Prof. Hill's personal researches in science have, of course, been centred on fundamental physiology, largely in terms of thermodynamics. These have no specific mention in this collection; but the

enthusiasm for physiology, and for experimental science as a whole, which they have kindled in him, warms and colours all the wider interests and all the wise and generous human impulses which are here displayed. And, together with its major components, Prof. Hill, with an impatience for stolid conventions which his friends and admirers have learned to expect, has included in his book quite an array of the records of his random effusions and explosions—a journalistic *canard* involving the apparent loss by the late Prof. Donnan of his famous equilibrium, letters to *The Times*, squibs, lampoons, parodies, shafts of scornful humour aimed at many targets. These too represent, indeed, a part of the essential "A. V.". It is to be hoped that they will give enjoyment to many readers, widely beyond the circle of the professional scientists, but all capable of responding to the more serious challenge and stimulus of the book as a whole. My only personal complaint of it is that I have found it rather heavy in the hand for reading in bed.

H. H. Dale

EDDINGTON: PHILOSOPHER OR PROPHET?

The Philosophy of Science of A. S. Eddington

By John W. Yolton. Pp. xiii+151. (The Hague: Martinus Nijhoff, 1960.) 11.50 guilders.

MORE than fifteen years after Eddington's death there is still an Eddington problem. The problem has changed somewhat, it is true, but has not become less puzzling. At first—during the last ten years of Eddington's life—it seemed as if the right question to ask was, 'Has he done what he says he has done?', and immediately after his death this assumed in many people's minds the less scientific form, 'Can he have done what he said he did?'. Now both these questions seem to be answered by a more or less firm negative; the more interesting question, 'Is it possible to formulate the idea of a theory of Eddington-type, in such a way that it will be a significantly new type of theory giving a greater insight into science, but at the same time one which will indeed be possible?', is that of most immediate interest. Roughly, a theory of Eddington-type would mean a theory which seeks to exploit to the full any limitations imposed on the propositions of scientific theories by the methods employed in making the experiments. Such a theory would need to discuss this kind of limitation very carefully: and, because we must understand 'proposition' here in a very general sense to mean a thought, sentence written or spoken or a manipulation with bits of the physical world, a theory of Eddington-type must itself be in a sense a philosophy of science—but not in the sense usually meant.

Before such a plan could be carried out we should need to get one 'white elephant' out of our path: that is, the fact that Eddington himself philosophized not 'in' what he was doing, but 'about' what he was doing, and not always in a very consistent manner. The present book is of some assistance here. It is a revised version of the essay which won first prize in the Belgian Eddington competition, and it seeks to show this self-conscious Eddington philosophy in its correct, essentially British, context. Locke and Hume are shown as the ancestors of a theory of knowledge, the most recent professional exponents of which include Russell. "Any analysis of Eddington's philosophy of science must recognize the twin strands of operationalism and dualism in his thought and must appreciate the possibility of uniting them . . . [by] . . . a careful analysis of dualist meaning." Such a discussion gets us no nearer to an appreciation of scientific theories of Eddington-type, but the author is clear and comprehensive in his purely philosophical task. C. W. Kilmister

HENRY CAVENDISH: HIS LIFE AND SCIENTIFIC WORK

Henry Cavendish

His Life and Scientific Work. By A. J. Berry. Pp. 208+4 plates. (London: Hutchinson and Co. (Publishers), Ltd., 1960.) 35*s*. net.

IT is more than a century since George Wilson published (under the auspices of the Cavendish Society) his *Life of the Honourable Cavendish* in which he remarked on the paucity of information regarding the man himself. It is a careful and thorough piece of work, so it is not surprising that no further attempt was made to write a life of Cavendish, at least until after 1879, when there appeared Maxwell's edition of Cavendish's electrical researches, for the most part not previously published, hence unknown to physicists before that date. This revelation would have led, one might have thought, to a revaluation of the place of Cavendish in the history of science, adapted to the needs of those not having the detailed knowledge to read the *Collected Researches*, a further volume of which, *Chemical and Dynamical*, appeared with a revised version of the former in 1921. Mr. A. J. Berry's book can be said quite literally to fill this long-felt want.

Of Cavendish's life and personality little more could be added to what Wilson had written, but the new presentation of the evidence should at least dispel the common opinion that the sole occasions of Cavendish's emergence from Clapham Common were his attendances at the Royal Society Dining Club. Whenever and wherever a scientific matter was involved, Cavendish was an active and often a leading participant. Perusal of the Council minutes of the Royal Society reveals his very regular attendance at meetings of that body over two separate periods of several years; that he was chosen several times as one of the auditors of the Society's accounts; and was a member of the committees 'on measuring the attraction of hills and mountains', the protection from lightning of the Purfleet powder magazines, the disposal of meteorological and magnetic recording instruments at Somerset House, the flooring of powder mills such as Waltham Abbey, the 'erosion' of the gold coinage and the thermometric scale. Above all, he regularly took part in the 'Visitations to the Royal Observatory', and his name is usually prominent where a report on any special instrument was called for. Many of these duties, as also some of his private researches, involved a good deal of travel. Finally, the fact that a year before his death he was asked to join the group within the Royal Society known as the 'Society for the Promotion of Animal Chemistry' suggests that he was

a colleague with whom other scientists, at least, found it a pleasure to work.

After a preliminary sketch of the state of science in the eighteenth century, Mr. Berry deals with Cavendish's researches under the separate heads of chemical, electrical, thermal, meteorological, and dynamical. In the case of the chemical he wisely devotes a separate chapter to the discovery of the composition of water. This *cause célèbre*—on the relative priorities of Watt, Cavendish, and Lavoisier—might have been thought to have been settled by the report of Lavoisier, Laplace, and others to the Paris Academy in 1790. But it is still necessary to express Cavendish's discovery in guarded terms, owing, as Mr. Berry reminds us, to the "question as to what Cavendish understood by phlogiston".

In his chapters on the research on electricity and heat (for the most part unpublished by Cavendish) Mr. Berry brings out admirably the peculiar nature of Cavendish's genius, revealed by his deep understanding of the distinction between what we should call the intensity and capacity factors of electricity and heat; the theory of divided circuits involving an implicit application of Ohm's Law; the equivalent conductivity of electrolytes; the better-known work on dielectrics; and, perhaps most remarkable of all, the thermal properties of heterogeneous systems, leading to the recognition of the existence of definite hydrates crystallizing at 'points of easiest freezing'.

Mr. Berry succeeds in bringing all this neglected work to life in a highly readable manner without historical distortion. The book is well produced; one must, however, regret that a book which should have a wide appeal must be sold at such a relatively high price. WILLIAM P. D. WIGHTMAN

HOMAGE TO SHERRINGTON

The Discovery of Reflexes

By Prof. E. G. T. Liddell. Pp. vi + 174. (Oxford: Clarendon Press; London: Oxford University Press, 1960.) 30*s*. net.

THIS is a book of scholarship and insight that has been written as a "tribute to the life and work of Charles Sherrington. It is not a text-book and it is not a biography. . . ". As I have read the book, it has appeared to me to have more the dramatic quality of an epic. It is with consummate skill that Liddell has set out to survey the development of scientific thought in the attempt to understand the essential features of the structure and function of the nervous system.

This historical outline of neurophysiology falls into two parts: the first, before Sherrington's time, showing the system of beliefs that were current at the outset of his active life; the second, during the first twenty years of his active life—that is, up to the appearance of his great book *The Integrative Action of the Nervous System*. In the first three chapters of the book, Liddell traces the development of three separate modes of investigation which were to be fused together by Sherrington.

In these days of electron-microscopy, the investigations of histologists even a hundred years ago look extremely primitive. Yet a few years later Deiters, "the forgotten histologist" as Liddell calls him, was drawing pictures of nerve cells that have never been surpassed in accuracy and beauty. One can be confident that the classical flowering of neurohistology would have been a generation earlier, but for Deiters' tragically premature death at the age of twenty-nine. So the first chapter of the book closes in the last decade of the nineteenth century with the development of the twin concepts of the neurone and the synapse. The independence of the neurone, as established particularly by Cajal, led Sherrington to postulate the functional connexion at the zones of very intimate contact, the synapses, that had been seen by Held and Auerbach.

The third chapter, "Experimental Approaches", describes in great detail not only the experiments but also the controversies that abounded in nineteenth century neurophysiology. In retrospect, one can regret that so much heat was generated where there was often so little light, and one can at the same time be sobered with the thought of how poor our present efforts may look after a further century of retrospect. Bell, Majendie, Marshall Hall, Müller, Grainger, Pflüger are the dominant figures, and the young Sherrington must have recognized the muddled thinking and the unjustifiable arguments that characterized much of the literature. Yet Liddell surmises that the seeming confusion would have been mitigated, because Sherrington would have the advantage of Michael Foster's *Text-book of Physiology* and of a remarkable book by Vulpian, *Leçons sur la physiologie du système nerveux*, which Sherrington remembered with pleasure all his life. One can sense that Sherrington owed much to his early exposure to the thoughts of Vulpian on the nervous system.

By contrast with these two main influences on Sherrington, the second chapter, on "Animal Electricity", is of less interest, and this certainly reflects the impression it must have made on Sherrington. Electricity certainly provided him with convenient stimulating devices; but, even at the end of his scientific life, electrical recording was primitive and he made very little use of it. His great contributions were based on the analysis of muscular contractions.

After the three chapters that formed the background on which the performance of Sherrington is to be staged, Liddell introduces Sherrington in this remarkable way. "In the year 1879 two events took place, which, though quite unrelated at the time, may both seem now, seventy years after, to have been significant for the science of neurology. The first was the appearance of volume 1 of *Brain, a Journal of Neurology*. It contained, as it happened, a paper by George Henry Lewes on 'Muscle Sense', an old problem which in due course engaged the attention of Sherrington and others after him. The second event was the admission of Charles Scott Sherrington to Cambridge, at the age of twenty-one." . . . The chapter so introduced was to me of particular interest because Liddell himself naturally adopts a personal relationship to his subject. So much that he writes about Sherrington comes from that understanding which derives from the close personal relationship that existed between Liddell and Sherrington during the Oxford phase of Sherrington's life. We can see how quick Sherrington was to grasp the significance of the organization that was being revealed in the central nervous system by Cajal, von Kölliker, van Gehuchten, Golgi and others. The story that Liddell has told shows how the young Sherrington applied all this new knowledge with unerring intuition so that he was able to build up,

in a few years, the basic concepts of reflex function that have formed the foundation of the neurology that we know to-day.

We are indeed grateful for a book with such insight and appreciation of the atmosphere in which Sherrington found himself in the latter nineteenth century and of his amazing creative achievements at that same time. Liddell has made this formative period of modern neurology live for us in a way that no one else could and we must be very grateful to him for it.

The book is very well produced, and there is a most valuable biographical appendix. J. C. ECCLES

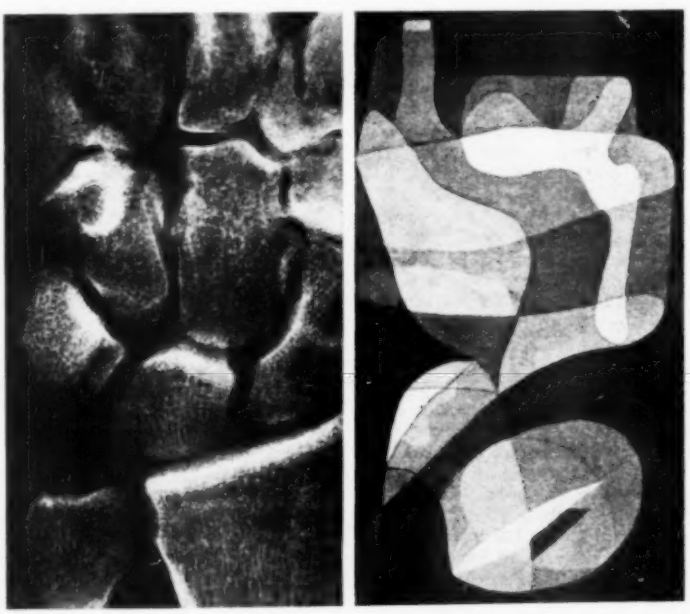
FORM IN ART AND NATURE

Kunst und Naturform (Form in Art and Nature) Herausgegeben von Prof. Georg Schmidt und Prof. Robert Schenk. Pp. 134 (68 tafeln). (Basel: Basilius Presse, A.G., 1960.) 68 francs.

THE problem of form in art and in Nature has been discussed in one sense or another at least since the period of the Egyptian dynasties, and one wonders whether the discussion had a counterpart even among the Aurignacian and Magdalenian artists. In the twentieth century there have been a number of works which approach the problem from various angles, commonly from a mathematical point of view. Among these we may recall Colman and Coan's *Nature's Harmonic Unity*, Cook's *The Curves of Life*, Hambidge's essays on *Dynamic Symmetry*, Irma Richter's *Rhythmic Form in Art*, P. E. Nobb's *Design: a Treatise on the Discovery of Form*, D'Arcy Thompson's *On Growth and Form*, Loran's *Cézanne's Composition* and others.

The book under notice provides a novel approach, because it makes a comparison between photomicrographs and modern non-representational paintings (or sculptures). It originated in an exhibition held in the Kunsthalle at Basle in 1958, and entitled "Form in Art and Nature", where the same comparison was made on a larger scale. The book provides short introductory articles by Willy Jäggi, Adolf Portmann, Georg Schmidt and Robert Schenk, followed by a series of well-printed plates, many of them in colour. The plates are arranged in pairs, so that on each left-hand page is a photomicrograph of some plant, animal or mineral subject, faced on the right-hand page by a reproduction of a work of art (usually a painting). The painters represented include Cézanne, Braque, Picasso, Mondrian, Matisse, Kandinsky, Klee, Giacometti, Jackson Pollock and various others, and the designs illustrated include a number of successful and attractive patterns and textures, mostly of the type covered by the term 'non-representational', though classified here under several headings. The aim of the exhibition and of the book has been to demonstrate a close similarity between forms revealed by the microscope, and those to be seen in the work of certain artists; and to comment on this resemblance. It is not claimed that photomicrographs or sections seen by artists under the microscope actually inspired the designs which resemble them (though this must have happened occasionally), but that the works of art came to resemble the microscopic preparations because of the "prevailing intellectual climate" of the twentieth century.

Now the pictures in this book are instructive, attractive, and intriguing; the text is sensible and thoroughly interesting; but I think none the less that the conclusions should be challenged. In the first place I believe that many of the pairs of pictures are not genuinely comparable. *Some* of them are (so much so that their independent evolution is remarkable); but in other cases comparisons are made which seem to me quite invalid. For example, Cézanne's "Sous-Bois" seems peculiarly unlike the photomicrograph of deformed brass printed opposite to it. The same applies to comparisons between Braque's "Paysage à l'Estaque" with the minute surface-structure of aluminium, and between a cubist Picasso and another aluminium surface. Again, an X-ray photograph of the human wrist-bones—hard, bony, three-dimensional and fibrous—is compared with a design in flat washes by Paul Klee, which shows a delicately coloured pattern of irregular shapes having no fundamental resemblance to the X-ray picture (Fig. 1). Further, a rigid, angular skeletal structure attributed to a marine isopod is compared with a pattern of coloured areas by Poliakoff which entirely lacks the hard, three-dimensional sculpture of the skeleton. But whether the painted pattern resembles a microscopic prepara-



A *B*

Fig. 1. *A*, X-ray photograph of a human wrist. *B*, Paul Klee: "Lichtbreitung" (1929). (From *Form in Art and Nature*, pp. 106–7)

tion more or less closely, one feels that on the whole the comparison is fallacious because the natural object has a structure and function depending on certain peculiarities of its own such as rigidity, tensile strength or elasticity, rendering its fine structure (which is 'representational' of a certain architecture and function) fundamentally unlike the work of art which, being 'non-representational', is a pattern or texture representing no structure and function. To me it seems that the comparison is superficial and meaningless (although undoubtedly intriguing), that no conclusion can be based on it, and that it has nothing to do with the "intellectual climate" of our century. I feel that it is allied to the view so often presented to us by art critics that modern artists of certain types reveal to us 'fundamental natural forms' which underlie the real natural shapes which we see. A biologist who has studied plant and animal forms in great detail over many years may well agree that Nature has 'fundamental forms'; but he knows more or less clearly what these forms are, and is less likely to agree that modern art reveals them. For example, when Henry Moore carves something intermediate between a human figure and a pelvic girdle, I believe that he is making a plain mixture of superficial natural forms and not revealing anything fundamental: this is merely an interpretation, not a criticism. Similarly, I believe that the similarities in the book under review, in so far as they exist at all, are accidental, and reveal nothing fundamental.

This conclusion has no element of antipathy to the works of art in question, many of which I find fascinating or even beautiful in themselves, just as the photomicrographs are fascinating in themselves. But to me they are two independent series. I think that some of the earlier books dealing with form in art and Nature may have approached the truth more closely than this one, though nobody has yet solved the problem.

T. A. Stephenson

SCIENCE IN PROGRESS

Science in Progress, Eleventh Series

By Armand J. Eardley, Richard J. Russell, J. Tuzo Wilson, Serge A. Korff, C. M. Jansky, Jr., Gerald S. Hawkins, Alfred C. Redfield, B. F. Skinner, Roger J. Williams, E. Cuyler Hammond, J. W. Beard, John Turkevich and A. C. Zettlemoyer. Edited by Hugh Taylor. (The Society of the Sigma Xi devoted to the Encouragement of Research in Science. National Lectureships 1957 and 1958.) Pp. xii+379. (New Haven, Conn.: Yale University Press; London: Oxford University Press, 1960.) 60*s*. net.

THIS book will appeal to professing amateurs and to amateur-professionals—to those who, as a cultural exercise, are interested in science and what is happening in various fields; and to those scientists who are interested in developments outside their own specialities. Since it consists of essays which are surveys and re-appraisals, it will not tell those working in the selected subjects much that they did not already know.

A Greek scholar (say) would find the three contributions on the earth-sciences (Eardley's "The Cause of Mountain Building"; Russell's "Instability of Sea-Level"; and Tuzo Wilson's "Continental Growth") intelligible and informative. A professor of theology, bracing himself for the disputations on "steady state", would be well briefed on techniques of radio astronomy by reading Gerald S. Hawkins, with a side-interest in "Origins of Cosmic Radiation" (Korff), but he might feel that he was getting more insight into C. M. Jansky, jun., than into his brother Karl and "The Beginnings of Radio Astronomy" about which he was supposed to be writing. The student of geophysics would feel less rewarded, since the work reflects only the thoughts and activities aroused by the International Geophysical Year and little, if any, of the findings.

On the other hand, he, or any exact scientist, would surely find Williams's "Chemical Anthropology" engrossing and challenging. Here is the proposal for the "marriage of chemistry and anthropology". Neither physical nor social anthropology will be superseded but something new will be added. The study of human beings in terms of their biochemical individuality can be said to have started with Landsteiner's discovery of blood groups, but now, with insight into enzymes, endocrine glands and all the subtle differences in the body-chemistry, the chemist should be able to assemble the kind of information which would explain the 'eachness' of all of us. One thing which Williams shows is that there is no such thing as the 'average man'. Skinner complements this with "The Experimental Analysis of Behaviour".

Not only does the environment determine the conditions under which life exists, but also reciprocally the organisms influence the conditions prevailing in their environment. From that, Redfield proceeds to show how the chemical factors can be influenced biologically. Conversely, Hammond's masterly paper on the statistics of smoking and lung cancer might be said to show how biological factors can be influenced chemically. In the ultramicroscopic environment, we have Beard on "Viruses as a Cause of Cancer", and Turkevich on "The World of Fine Particles" and, to finish up, Zettlemoyer on "Molecular Interactions with the Surfaces of Solids".

Of course, as in any symposium, the quality of presentation varies, but in general it can be said that any intelligent person can have his ignorance of any of the subjects illumined.

Ritchie Calder

THE BRITISH ECONOMY IN TRANSITION

British Industry

Change and Development in the Twentieth Century. By Dr. J. H. Dunning and C. J. Thomas. Pp. 232. (London: Hutchinson and Co. (Publishers), Ltd., 1961.) 30*s*. net.

THIS survey of the changes in the British economy since 1914 manages to cover a very broad field in a little more than 200 pages. The topics include industrial structure, ownership and location, energy and power, research and trained man-power, new materials and processes, the State and industry, and international aspects. Drawing on a wide range of sources, the authors have given a clear quantitative picture of developments under each

of their main headings. The book is intended for first- and second-year undergraduates reading economics, as well as the layman interested in British industrial development in general.

The authors find that British industry in 1914 was "structurally maladjusted in relation to the world economic trends then emerging", and it is inferred that this was a major reason for the relative stagnation between the wars. A comparison between the rate of industrial growth of 2 per cent per annum between 1880 and 1913 and 3–4 per cent per annum between 1815 and 1876 is taken to indicate a falling behind in the race: Britain had become "over-specialized"; her share of world trade in manufactured goods fell from 38 per cent to 27 per cent between 1876 and 1913; in this period, too, a large part of her investments were directed to the Dominions, South America and the United States, "principally at the expense of domestic capital formation". This assessment is not free from internal contradictions. The fall in Britain's share of world trade was simply a reflexion of the arrival of new large countries in a much-expanded world; and this share would have shrunk more if she had not indulged so liberally in foreign investment. Moreover, it is misleading to characterize capital exports over the period 1870–1913 as being principally at the expense of domestic capital formation. There was an inverse relation between long cycles in home and foreign investment in that period, and so one might just as well say that in certain phases of the cycle domestic investment was at the expense of foreign. It would have been better if the authors had inquired to what extent the organization of the British capital market in the pre-1914 period set a premium on capital exports.

Most readers will be interested in the contrast between recent industrial growth and the stagnation of the inter-war years; within its compass, the book gives a clear account of the most striking new features. It succeeds very well in describing technical progress in reasonably non-technical terms. It is salutory to be reminded that, at the peak of full employment in 1955, coal imports rose to £73·7 million (some £20 million more than coal exports), and that the revision of projected atomic energy investment in 1960 cut the earlier programme by half. There is one singular omission in the analysis of resources; nothing is said of the bearing of water supplies on the growth of industry and agriculture.

On Britain's external economic problems in recent years the argument is uneven. On p. 211 we learn that Britain has increased her share of the expanding group of export trades by more than that of any of her major competitors; on p. 217 we are told that two-thirds of Britain's export trade is with "the poorer and less highly industrialized countries whose people have comparatively simple tastes" and so it is not surprising that Britain's share of total world trade has been falling. The analysis would have been clearer if the authors had been less impressed by the significance of changing 'shares' and more concerned with the movement of the terms of trade corrected for productivity changes in the export sector. One would have liked to have, as a concluding section, a more thorough examination of Britain's dilemma concerning the European Economic Community.

Brinley Thomas

STRUCTURE AND FUNCTION OF MUSCLE

The Structure and Function of Muscle

Edited by G. H. Bourne. Vol. 1: Structure. Pp. xvi+472. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1960.) 14 dollars.

THIS volume contains chapters contributed by a number of eminent workers. It is obviously impossible to deal with all aspects of muscle in any one book, but a better balance could have been obtained. Recent findings with the electron microscope dominate throughout. Apart from a description of the motor end-plate, there is little reference to the innervation of skeletal or smooth muscle. The difference between phasic, tonic and slow muscle is dealt with in less than a page.

The volume is entitled *Structure*, but it has proved difficult to separate structure from function. Indeed, the value of a book of this kind is in the integration of structure with function. The chapters in which this has been done are excellent.

Chapters 1 and 2 contain good general descriptions of the anatomy of whole muscles and their relation to movement, and of the micro-anatomy of muscle. Both appear to have been written with the student, rather than the experienced worker, in mind, and in this they are out of keeping with the rest of the volume. The development of striated muscle is dealt with in Chapter 3, which makes difficult reading; more diagrams would be helpful. Chapter 4 is a résumé of the histochemistry of developing muscle, with good illustrations. The significance of the findings merits attention in greater detail. Chapter 5 is a clear exposition of the structure and behaviour of skeletal muscle in culture.

In Chapters 6 and 7 the structure of skeletal muscle, as shown by the electron microscope, is described in detail, emphasis being placed on the sarcoplasmic reticulum in the former, and on the contractile elements in the latter. The presentation of Chapter 6 is outstanding, and forms an excellent pattern for an advanced reference work. Chapter 7 includes a clear description of the sliding filament theory of muscular contraction, and the figures are very good.

Chapter 8 deals with the difficult subject of smooth muscle, but is unnecessarily obscure. No clear picture emerges of what is, in fact, known, and detailed acquaintance with the literature is assumed. The problem of the relation and conduction between cells is not mentioned. Many figures are not referred to in the text and cannot be interpreted from the legends. A very good, comprehensive, review of the comparative anatomy, biochemistry and physiology of invertebrate and vertebrate muscle is given in Chapter 9. The subject is treated at a very advanced level, but is well presented, and a good summary is included.

Chapter 10 describes clearly the detailed structure of the motor end-plate, as demonstrated by standard staining techniques and by electron microscopy. There is no reference to the number of end-plates on different types of fibre, or to *en grappe* terminations. The structure and behaviour of muscle-spindles and other receptors in muscle are dealt with in considerable detail in Chapter 11, which is readily intelligible, nevertheless. The section on comparative physiology

of muscle receptors is particularly good. Chapter 12 is a convincing description of the evidence obtained from high-resolution electron microscopy that the intercalated disks divide cardiac muscle into definite cell territories.

Some chapters have excellent summaries, and uniformity in this would be helpful to less experienced readers. The practice of having magnification scales on the plates should be used throughout. Printing errors are few; the author index page numbers referring to the last three chapters are two pages out. Several chapter page headings are not sufficiently specific.

The book is not, and is not intended to be, a text-book on muscle; it is an encyclopaedic reference work. The aim of providing a balanced source of information has not been achieved fully, and more uniformity in presentation is desirable. Nevertheless, the volume contains much excellent material of value to those who work with muscle, and Chapters 7, 10, 11, and the summary to Chapter 9, should be read by all advanced students and teachers.

I. A. Boyd

CELL TISSUE AND ORGAN

Notions de Cytologie et Histologie

Par Prof. M. Chèvremont. Réimpression 1960. Pp. iv+991. (Liège: Éditions Desoer, 1960.) n.p.

DURING the past twenty years or so, the microscopic investigation of form and function has made tremendous strides through the invention of new methods. Their influence on cytology and histology is reflected strongly in this interesting and important book.

The text is divided into three main sections, and of these the most noteworthy is perhaps the first; it certainly imparts to the rest a special, if not a unique, flavour. It comprises a series of chapters on the cell. Since the author has had long experience of work with the ciné-camera and tissue culture, it is not surprising to find that reference is continually made to events in the living cell and that dynamic aspects of structure are preferred to discussion of morphological minutiæ. In this section are many striking illustrations taken from the author's motion picture studies. Among the early chapters is a full and detailed account of histochemical techniques, the results of which are illustrated by many excellent colour plates. Unfortunately, owing to rapid developments since the book was written, this is already out of date; nevertheless, it indicates the general aims and potentialities of histochemistry. Since original publication there has also, of course, been an almost explosive growth of information from the electron microscope following on perfection of techniques for ultra-thin sectioning. The next edition will call for the inclusion of better illustrations and more mention of such topics as the endoplasmic reticulum and the newer views on the structure and function of the Golgi apparatus.

The second part deals with the basic bodily tissues, and the third with organs and cell systems. The approach is consistently dynamic; attributes of the living tissues are discussed continually and further accentuated by description of their behaviour *in vitro*. A chapter in the third section which will naturally be read with great interest concerns the 'histiocyte' system, to use the word preferred by the author for 'reticulo-endothelial'. Prof. Chèvremont's intriguing views on the transformation of comparatively specialized cells, even muscle or epithelium, into wandering phagocytes are here expressed in a stimulating fashion.

Minor criticisms are that although many names are quoted in the text there are few bibliographical references, and that some of the photomicrographs might with advantage be replaced by diagrams. However, there is no doubt that the postgraduate student and junior staff member particularly will find the book invaluable, as would anybody wishing to assess the present status of the subject. Inevitably, since they have held the field so long, comparison of this book must be made with the trans-Atlantic manuals. It would be fair to say that the illustrations on the whole are inferior; however, the text is written in a more adult style than some; but the principal difference, stemming from the first section, seems to lie in the continual reference back to the functional attributes of individual cells. Indeed, the inclusion of such a lively and interesting introduction to cytology within the covers of a book on histology raises questions about the relationship between the two. For example, How much cytology ought the student to know before embarking on histology? The latter, of course, deals mainly with the arrangement, maintenance and function of cell populations, and seeks by experiment to identify the controlling factors. In the majority of standard books the cell itself is still dismissed quite shortly. Neglect of the brick when little was known about it and concentration on the edifice may have been unavoidable a generation ago. Now, however, there is a mass of knowledge about cells which is of absolutely basic importance; basic for the graduate in biochemistry, physiology, biology, and basic for the medical student with his additional interest in abnormal cells. Prof. Chèvremont has erected a signpost. In most histology laboratories in Britain, unfortunately, it cannot be followed until additional curriculum time and staff are provided.

N. M. Hancox

ANIMAL HUSBANDRY

Animal Husbandry Heresies

By Dr. Allan Fraser. Pp. 200. (London: Crosby Lockwood and Son, Ltd., 1960.) 16s. net.

IN twenty short essays the author criticizes in a most interesting way many current beliefs in animal husbandry. Both the practical and scientific aspects of animal production are covered under four main headings—inheritance, environment, husbandry and purpose. After discussing early breed improvement and Bakewell's methods of inbreeding and progeny testing which led to the formation of breed societies, the latter are criticized for paying too much attention to the trade-marks of colour and form rather than to commercial qualities. It is pointed out that the recent extension of such breeds as the Clun sheep and Friesian cattle are due to the latter. Exhibits at shows of dairy bulls, poultry and sheep without production records are considered futile. Dr. Fraser is critical of the authenticity of many pedigrees in the past, but does not mention the new blood-group test.

Geneticists come under fire. From a production point of view the postulation of new genes gets us nowhere, and, although progeny tests are useful, the method of their application needs further research. In man the differences in physique at different class-levels are due to the environment of rearing and but little to genetics; this is also true for animals. Certain environmental effects, such as vitamin deficiencies, may be passed on to the next generation, as may maternal effects such as size in horses. His main criticism of present-day genetics is that it does not give enough credit to environment, both external and internal, for it is only the provision of proper nutrition which allows the full genetical potential for production to be expressed.

The science of animal nutrition places too much faith in rationing on tables of food analysis which are based on chemistry and not enough on the biological value to the animal; this is the case with non-protein nitrogen. The present distinction between maintenance and productive rations needs a new outlook, for a cow can draw on her body for milk production. The transition from peasant to mechanized animal husbandry, which has not yet proceeded far enough in Great Britain, is outlined and the losses and gains assessed. On the medical side, it is doubted whether the protective value of foods, such as milk and eggs, is as good as it used to be before intensive methods of production were employed. The author's description of hill ewes at the end of winter as being "pregnant skeletons concealed in wool" is typical of the force with which he makes his points.

The book is provocative, for there is just cause for some of his criticisms, while for others, one hopes that they will stimulate replies from the specialists concerned. JOHN HAMMOND

BROADLEAVED TREES OF BRITAIN

Guide to British Hardwoods

By Dr. W. B. R. Laidlaw. Pp. viii + 240. (London: Leonard Hill (Books), Ltd., 1960.) 30*s*.

THE main purpose of this handbook is to provide students, foresters, and others interested in the subject with a ready and accurate means of identifying the broadleaved trees of Britain. This is achieved with notable success for, although the range of subject-matter is wide enough to attract the interest of those who have a fairly extensive knowledge of botany, the presentation is so clear that the intelligent novice should have little difficulty in using it to identify all but the least commonly found trees and shrubs.

To some the title of the book will seem misleading. Does not the term hardwood suggest a discussion of timbers and the trees which produce them? But here is a field approach to the whole range of native broadleaved trees and shrubs together with those which have become so well established in Britain that they form a regular feature of its countryside, parks, and gardens, and there is also a carefully made selection of less frequently seen introductions. Only brief references are made to the qualities of the timber for which many hardwoods are of importance (Are all the major hardwoods really in such short supply as the writer would have us believe?), and none to structural features.

All characteristics not considered essential for identification of the species in the field in all seasons have rightly, in a book of this kind, been discarded for the sake of clarity, but no trouble has been spared to show how the essential features may be used, through several lines of approach, for accurate identification. There are, for example, separate keys based on winter bud and twig details, summer characters, and fruits, summarized field characters in a concise tabular form, a table of seasonal characteristics, and the short, but adequate, descriptions of each species. One of the most outstanding features of the book must be the beautifully drawn and reproduced illustrations of leaf, flower, etc., in fine detail but with commendable clarity. The omission of any scale is, however, most regrettable.

For the beginner there is a short account of botanical anatomy and morphology. This is necessarily very condensed, and the beginner may find a little difficulty at first in absorbing parts, but such features as leaf- and flower-form, used extensively in identification of species, are given more fully. Together with the glossary of terms elsewhere in the book, the student should have sufficient background information to enable him to make full use of the main part of the work.

Those who are familiar with the commoner trees will find much of interest in the less-known species which the writer was, fortunately, persuaded to include, and will be most grateful for the more complete treatment given to the complex problem of identifying the willows and poplars.

J. L. DAVIDSON

ADVANCES IN PLANT PHYSIOLOGY

Annual Review of Plant Physiology

Vol. 11. Edited by Leonard Machlis, in association with Winslow R. Briggs. Pp. vii + 468. (Palo Alto, Calif.: Annual Reviews, Inc., 1960.) 7 dollars.

WITH the present volume of the *Annual Review of Plant Physiology* this useful publication enters the second decade of its existence. As in past years the subjects dealt with range widely over the whole field of plant physiology. This volume of the *Review* has very much an international character, for the contributors have been drawn from no fewer than ten countries. Five of the contributions are from the United States, three from England, two from Germany and one each from Australia, Canada, Denmark, France, Japan, New Zealand and the U.S.S.R.

Of the seventeen articles, nine are concerned with various aspects of metabolism, which include the primary processes of photosynthesis discussed by A. A. Krasnovsky, and energy transfer through phosphorylation mechanisms in photosynthesis by O. Kandler. Nitrogen metabolism is represented by a short article by C. S. Yocum in which recent advances in knowledge of nitrogen fixation are considered, while the special metabolism of the succulent Crassulaceae is reviewed by S. L. Ranson and M. Thomas. Articles on transport in the xylem and in the phloem are contributed by E. G. Bollard and M. H. Zimmermann respectively, while the

relationship between salt uptake and water absorption by intact plants is dealt with by R. Scott Russell and D. A. Barber. A less-familiar subject, that of heat transfer between the plant and its environment, is discussed by K. Raschke. Another topic to which not much attention has been previously given in the *Review*, and the account of which by A. C. Neish is therefore of particular value, is that of the formation and inter-conversion of aromatic compounds in plants.

Articles on growth and development again include accounts of certain aspects of auxin and gibberellin action, the former by A. W. Galston and W. K. Purves and the latter by B. O. Phinney and C. A. West, while P. Chouard contributes an interesting discussion on vernalization and its relation to dormancy.

An innovation in the present volume is the grouping of the articles in the list of contents under a number of main headings. Under the heading "Cell Structure and Function", F. Mercer writes on the submicroscopic structure of the cell. In this, particular attention is naturally directed to the contributions made by electron microscopy to the elucidation of the fine structure of the cytoplasm and its inclusions. Another subject which might well have been included under the same heading, but which actually appears under the heading of "Special Topics", is the physics and chemistry of protoplasmic streaming by that authority on the subject, N. Kamiya. Another special topic considered is the productivity of the oceans, discussed by E. Steemann Nielsen. The two remaining articles concern tobacco mosaic virus and pectic and cellulolytic enzymes in plant disease, the former contributed by A. Siegel and S. G. Wildman and the latter by R. K. S. Ward.

What will be found particularly useful in this volume is an index of all the articles which have appeared in the eleven volumes of the *Review* that have so far appeared. The value of this index is enhanced by the grouping of the titles of the articles under twelve main subject heading , which makes reference easy. WALTER STILES

THE FLORA OF THE PACIFIC STATES

Illustrated Flora of the Pacific States

Washington, Oregon, and California. By Leroy Abrams and Roxana Stinchfield Ferris. Vol. 4: Bignoniaceae to Compositae (Bignonias to Sunflowers). By Roxana Stinchfield Ferris. Pp. vii + 732. (Stanford, California: Stanford University Press; London: Oxford University Press, 1960.) 140*s*. net.

IN North America, at least, it has been a relatively rare phenomenon for an incomplete Flora to survive the death of its author and be brought to completion. Asa Gray's *Synoptical Flora* and N. L. Britton's *North American Flora* come to mind as examples of great works, valuable even in their incompleteness, but incomparably less valuable than they would be had they been finished.

It is, then, a real pleasure to record the completion of Leroy Abrams's *Illustrated Flora of the Pacific States*, for its author died in 1956, and had been in poor health since 1948. It is some measure of the respect that he commanded, and of the affection that he inspired, that this fourth and last volume was carried through to completion by a number of distinguished contributors and by Abrams's friend and assistant of forty years standing, Roxana S. Ferris.

In 1910 the flora of the Pacific coast of the United States (California, Oregon, and Washington) was not well known. Nevertheless Leroy Abrams, at that time assistant professor (that is, a lecturer) in botany at Stanford University in California, began work on an illustrated Flora which he hoped would do for the Pacific Coast what Britton and Brown's *Flora* had done for the north-eastern United States. Abrams was not unacquainted with the flora of western North America and the difficulties that its study entailed. He had already published a *Flora of Los Angeles and Vicinity* and had just completed *A Phytogeographic and Taxonomic Study of the Southern California Trees and Shrubs* for which Columbia University in New York City had awarded him the Ph.D.

As a research student in New York, Abrams had known N. L. Britton, and had become acquainted with Britton and Brown's *Illustrated Flora of the Northern United States, Canada, and the British Possessions*, a work which aimed ". . . to illustrate and describe every species, from the ferns upwards, recognized as distinct by botanists and growing wild within the area adopted . . . within such moderate limits of size and cost as shall make it accessible to the public generally. . . ." 'Britton and Brown', as it is affectionately known, may be taken as the culmination of a century of botanical study in the north-eastern United States. That the first volume of the first edition (1896) was issued within six years of the inception of the work, and that it was completed with a third volume two years later, is some indication of the amount of taxonomic knowledge that was available to the authors. The first edition of 1896–98 included 4,162 species. The third edition of 1952 covered about 4,680 species. This is another indication of the relatively complete knowledge of the flora of the north-eastern United States that existed at the turn of the century.

Despite the very considerable difficulties inherent in the study of an essentially unknown, though not unexplored, area, Abrams set himself, in 1910, to the production of an *Illustrated Flora of the Pacific States*. In contrast to the speed with which 'Britton and Brown' was written, the first volume of Abrams's *Flora* was not published until 1925, and the fourth and last volume did not appear until 1960. That the illustrations, the literature citations, and the text are accurate and that the keys work are a result of the integrity of Leroy Abrams. That there were many distinguished collaborators is freely acknowledged. The uniformly high standard of scholarship and the relative uniformity of treatment must be attributed to Abrams, who, alone or with the help of Mrs. Ferris, supplied about half the text.

In common with many, if not most, present-day American Floras, the plant families are treated more or less in the sequence adopted by Engler for his *Die Naturlichen Pflanzenfamilien*. Thus, Volume 1 of the *Flora* covers the ferns, the fern allies, the Gymnosperms, the Monocotyledons, and the beginning of the Dicotyledons from the Saururaceae to Aristolochiaceae; Volume 2, the Polygonaceae to Krameriaceae (the end of the Leguminosae, *sensu*

lata): Volume 3, Geraniaceae to Scrophulariaceae; and the present Volume 4, the Bignoniaceae to Compositae. Two bits of data appear noteworthy. First, the ratio of Monocotyledons : Dicotyledons is 1,019 : 4,884, or roughly 1 : 4·8, as contrasted with the north-eastern United States where the ratio is 1,415 : 3,955 or roughly 1 : 2·7, and with the south-eastern United States with 1,479 : 4,045 or also roughly 1 : 2·7. The statistics for the Gramineae are 78 genera and 389 species (1 : 5) on the west coast, 110 genera and 487 species (1 : 4·4) in the north-east, and 100 genera and 476 species (1 : 4·8) in the south-eastern United States. Thus it appears that the west coast of the United States is significantly poor in numbers and diversity of species of Monocotyledons. Secondly, Abrams lists 939 species of Compositae in 176 genera (1 : 5·3) as compared with the north-eastern United States with 703 species in 115 genera (1 : 6) and the south-eastern United States with 770 species in 150 genera (1 : 6). It appears that although there are more species and genera of Compositae (though there are fewer grasses) on the west coast of the United States, the generic and specific diversity is little, if any, greater there than in the east. This does not seem to support the thesis that semi-arid regions have richer floras, in terms of diversity, than more mesic areas. The relative paucity of grasses must also cast some doubt on the general validity of this thesis.

Abrams's *Flora* comprises 6,069 species of higher plants in an area of about 324,000 square miles. It is rather startling, for botanist and layman alike, to discover that a recently published Flora of California comprehends something more than 5,000 species in slightly less than half the area (about 158,600 square miles). A close comparison of the two works shows, however, that this does seem to be the case. For example, in the first 420 pages of the fourth volume of Abrams's *Flora* there are only about 100 naturally occurring species (out of 770) which do not occur in some part of California. This fact suggests that the primary job of cataloguing the flora is virtually completed, for the west coast as it is for the north east, and the taxonomist may now turn his attention to some of the other fundamental questions which Abrams's inventory has exposed (one cannot help wondering how long it will be before the flora of the other two-thirds of the United States is equally well catalogued).

The completion of Abrams's *Flora*, then, enables us to formulate some of the fundamental problems presented by the flora of the west coast of the United States. Why are the Monocotyledons so poorly developed in the area? What, precisely, is the real taxonomic status of the many 'endemic' species that occur in the area? How are they to be compared with other, generally accepted, species in the area and outside it? What, indeed, is a species? How are we to recognize one when we see it and how are we to measure it? Why have we been led to regard the west coast flora as an exceptionally rich one, when, on the testimony of its published Floras, it is no richer than many other comparable floras in its same latitude, both in North America and elsewhere? These, and many more, questions will present themselves to the thoughtful student of the flora of western America. He will be grateful that he has so reliable a guide as Abrams's *Illustrated Flora of the Pacific States*.

G. P. DeWolf

HYPOGEAN FAUNAS

Biologie des Eaux Souterraines, Littorales et Continentales

Par Claude Delamare Deboutteville. (Actualites Scientifiques et Industrielles, No. 1280.) Pp. 740. (Paris: Hermann, 1960.) 60 NF.

ORGANISMS which are to be found in the cracks and fissures of rock or within the voids of sands and gravels form the subject of this important new book. Delamare Deboutteville's *Biologie des Eaux Souterraines, Littorales et Continentales* brings together for the first time in a comprehensive and readable account the work carried out in the past thirty years by European and American zoologists on these little-known but widespread and important faunas.

He treats this niche as similar in character, whether it occurs beneath the ground, beneath the sea, or beneath the intertidal zone. Moreover, this environment is continuous between sea and land, so that organisms have been able to spread along it in the course of evolution. This view is shared by a number of other workers such as Angelier, Chappuis and Spooner, the last having coined the collective term 'hypogean', which may usefully be applied to all such faunas.

The book is divided into six parts. The first concerns the environment. After a useful survey of collecting methods it gives a well-illustrated account of the physical geography and hydrology of the habitat, together with a summary of what little is known of its physical and ethological conditions. Finally there are examples of the localization of the fauna on certain beaches.

The second and third section of the book are the most valuable for the general reader, and indeed should be read by all students of marine zoology. They include a fascinating account of the adaptations of hypogean forms, followed by descriptions of the wide range of animal life, with representatives of most of the invertebrate phyla, which are to be found in the interstices of sand and gravel. Some of the figures which illustrate only parts of such animals might, with advantage, have been replaced by figures of complete animals, but otherwise the survey is excellent.

The fourth and fifth sections are in monograph form, reprinted from *Vie et Milieu*. Though of some value to the specialist, their content could with advantage have been summarized for the general reader.

In the final part there is an interesting account of the segregation and speciation of faunas, showing how continental forms have been derived from marine species by passing along the continuous subterranean habitat.

Deboutteville does not pretend to include a complete bibliography, and even some text references are not cited; nevertheless, it will form a valuable starting point for new workers and research students.

This important and, for the most part, attractive work should help to bring to the notice of zoologists, especially in Britain where the subject has been neglected, the existence of a fascinating and important group of organisms which have as yet been studied only from the faunistic point of view. Their physiology, ethology and bionomics are virtually unknown.

D. J. Crisp
P. J. S. Boaden

FISH CULTURE

Traité de Pisciculture

Par Prof. Marcel Huet. Troisième édition. Pp. xii + 369. (Bruxelles: Éditions Ch. de Wyngaert, 1960.) 450 francs; 9 dollars.

IT is a pleasure to welcome the third edition of Huet's treatise on fish culture. The new material in this edition consists of some expansion of the section on the culture of *Tilapia* in tropical Africa, and new methods (using new synthetic herbicides) for controlling excessive vegetation in ponds.

The book is written for fish culturists in temperate climates, and this in effect means largely carp culture and trout culture. Carp culture has had adequate treatment elsewhere, for example in Wunder's *Fortschrittliche Karpfenteichwirtschaft*, (reviewed in *Nature*, July 8, 1950), so Huet is right in giving the most detailed treatment to trout culture. He devotes 63 pages of text and 62 plates to the subject—the largest section in the book. But he has by no means neglected other fish which are cultured, and has chapters or sections on carp, on tench and other fish which can be cultured with the carp, and on the culture of the pike, of coregonids, black bass, eel, and of *Tilapias* in tropical Africa. Huet interprets 'fish culture' in the wide sense, dealing with the raising of fry and fingerlings for the stocking of natural waters, as well as for raising to table size in ponds. Only the fancy-fish trade is omitted, and this has its own extensive literature.

The sections on general principles are useful and well illustrated. Chapter 1 deals with the construction and management of fishponds, on the choice of site, the levelling to be done, the sources and quality of the water, the soil, and the engineering work needed. The diagrams are especially useful. This theme is continued in Chapter 7, with accounts of pond maintenance and improvement, including the control of weed-growth, which may not only much diminish fish production, but can also lead to complete filling up of the pond.

There follow accounts of the 'dry period' and alternative crops, the use of lime and the reasons for it and the use of fertilizers to increase production. In my opinion, these sections could have been expanded; for at a time when labour costs are rising, and suitable fish-fodders are in many cases becoming more costly, the correct use of fertilizer is still the cheapest way of securing a large increase in the fish crop, and the possibilities are by no means fully explored.

Chapter 2 covers the food of fish in ponds, with some good illustrations of the most important food organisms. The treatment includes a brief account of the ecology of a pond and the nutritive cycle, and ends with the practice of supplementary feeding and a list of the most important supplementary fodders, their preparation and their nutritive quotients. Huet repeats the view that at least 50 per cent of the food of carp in ponds must consist of natural food, because the latter contains enzymes which assist the fish in the digestion of the supplementary food; but this is surely no longer accepted. The stomach-less carp nevertheless possesses a very effective range of digestive enzymes; in fact, recent work in Israel suggests that the carp is as efficient a digester of fodder as cattle. The unquestioned value of a high proportion of natural food lies partly in its high protein content, which means that supplementary fodder can consist largely of cheap carbohydrates, and partly in something resembling the 'animal protein factor' of the stock-raisers and poultry farmers, which may well be associated with vitamin B_{12}.

Chapter 3 deals with carp culture, Chapter 4 with trout culture, and Chapter 5 with the culture of other fish. Chapter 6 deals with rates of stocking and productivity, and emphasizes, among other things, the difficulty in assessing the probable natural rate of productivity of newly constructed ponds. A final Chapter, 8, covers the methods of fishing out of a pond, and the handling and transport of the fish.

This is a lot of ground to cover in 270 pages of by no means closely printed text (there are 93 pages of photographs), and I have no doubt that Huet has been obliged to exert rigorous selection of his material. The obvious success of the book has justified his treatment. The paper and format are excellent, and the 280 photographs are very well done. It is regrettable that the book has no index, and that the references to the literature are inadequately given. Perhaps these could be supplied in the next edition.

C. F. HICKLING

ECOLOGY OF SOIL FUNGI

The Ecology of Soil Fungi

An International Symposium. Edited by D. Parkinson and J. S. Waid. Pp. xi+324. (Liverpool: The University Press, 1960.) 42*s*. 6*d*. net.

NEARLY fifty years ago Waksman raised the problem of whether the soil is the home of an indigenous mycoflora, or merely the sink for fungus spores floating in the atmosphere. The answer, which he and subsequent workers gave, has been so clear that it has even been suggested that the fungal load of the atmosphere is largely derived from the soil population. The next phase of research on the soil fungi was largely floristic: the components of the mycoflora were identified and enumerated; the world-wide distribution of many species was established; floras characteristic of different soils and also of environments within soils (especially the rhizosphere and the roots of hosts susceptible to pathogenic fungi) were recognized. More recently, attention has been directed to research on the activity of fungi in the soil, and during 1958 a small group of workers was convened at the University of Liverpool for a symposium on the ecology of soil fungi. The publication of the proceedings of the symposium in this book emphasizes the value of such specialized meetings, although the value of including verbatim reports of the discussions is doubtful, as such matter is impermanent and often inconsequential.

The general picture of the soil fungi emerging from this symposium is one of populations consisting largely of resting organisms in a mosaic of micro-environments with micro-zones of antagonism, making little mycelial growth, but bursting into activity when some event brings fresh nutrient to resting cells able to exploit it. Small soil animals, root growth and litter accumulation play an important part in producing such events. Much of our present

knowledge of the activity of soil fungi comes from dilution-plating techniques, the limitations and merits of which, as well as those of alternative methods, are discussed in detail. All workers recognize that the traditional methods are highly selective, little able to discriminate between passive and active states of the organisms under study; hence the attempts to supplement plating techniques with visual microscopic methods, difficult as these are with an opaque medium such as the soil. Slowly we are gaining knowledge about the presence and mode of life of Basidiomycetes in the soil. It is even possible that a future book on the ecology of soil fungi would be mainly about the Basidiomycetes and Actinomycetes instead of the moulds which occupy the centre of interest at present.

Despite the unusually abundant misprints (not even insertion of the customary accents would remove the odd appearance of some passages in French), the large amount of original research presented here, with reviews of progress and methods, makes this a valuable and stimulating work.

P. H. Gregory

ILLUSTRATIONS OF FUNGI

Iconographia Mycologica

By O. Verona and T. Benedek (*Mycopathologia et Mycologia Applicata*. Volumes XI, XII, & XIII). (I) Plates *A*1–18; *B*1–10; *C*1–18; *D*1–4. (II) Plates *A*19–46; *B*11–23; *C*19–25; *D*5–6. (III) Plates *A*47–84; *C*26–33; *D*7–10. (Den Haag: Uitgeveij. Dr. W. Junk, 1959–60.)

THREE supplements to the journal *Mycopathologia et Mycologia Applicata* have recently appeared from the pens of O. Verona, plant pathologist, and T. Benedek, medical mycologist, under the title *Iconographia Mycologica*. These supplements consist of a series of folded sheets each containing drawings of characteristic features and a brief description of one or more selected genera of fungi. It is stated that the sheets are separate so that the owner has a choice in the manner in which he decides to arrange the collection. In fact, two systems of classification are given, one strictly orthodox and taxonomic; the other into the four categories: saprophytes, plant parasites, animal parasites and industrially important fungi. As a system of filing, this second arrangement would soon become impossible since some genera, for example, *Aspergillus*, fall into at least three of the four categories. Therefore the taxonomic system of filing is the only one that could be useful.

What, then, is the advantage in a loose-filing system here? It does allow additions to be fitted into the collection as these appear, but this is a dubious advantage since, if the rate of appearance of additions continues at a high level for long, the work as a system of identification is going to be incomplete and useless for just that long. If it is soon complete and up to date, then I see no advantage over the preparation of a complete book published at one time and ready for use, and in which the occasional minor change can easily be entered in hand by the owner. It seems, then, as though the work is not intended to assist in identification. This supposition is supported by the fact that there are no keys to groups, and while in some genera some species are mentioned, in others no specific epithet is given. Moreover, there are no references to works by which specific identity could be confirmed. One is left with the single conclusion that the main use for the loose-filing system is that sheets can be taken out as wanted with the aim of demonstrating or illustrating some point, presumably to an undergraduate class. The sheets here, then, serve the same functions that used to be performed by lecture-room wall charts and diagrams. It is doubtful that they perform these functions better for being smaller and monochromatic.

In fairness, it should be stated that the standard of drawing here is considerably higher than that found in illustrations to the more usual works of general identification such as Gilman's *Manual of Soil Fungi* and Barnett's *Imperfect Fungi*, but it is not so high as that which one has become accustomed to from the type of Commonwealth Mycological Institute publication issued under the names of E. W. Mason and S. J. Hughes, from which, incidentally, many of the illustrations in the present supplements appear to be taken.

David Park

HURRICANES

Atlantic Hurricanes

By Gordon E. Dunn and Banner I. Miller. Pp. xx+326. (Baton Rouge: Louisiana State University Press; London: Interscience Publishers, Ltd., 1960.) 75*s*.

THIS book has been written for the layman. The authors say that it is desirable he should have some meteorological background, and indeed already at the beginning of the second chapter he will encounter streamlines, contour lines and isotachs (should he feel at a loss, he can refer to a glossary of terms in an appendix), and then easterly waves and the Intertropical Convergence Zone. Still, his enthusiasm may have been stimulated by the first chapter, an eye-witness account of one of the most intense hurricanes of this century, and it is better that he should come to feel that his background could be improved than that the authors underestimate him.

The book continues as a well-illustrated, non-mathematical and very interesting account of practically all that is known about hurricanes and the related hazards of storm floods and tide surges, including how to prepare for, and ride out, these disasters. It becomes evident how much their study is now in the hands of American scientists, and in particular how the modern techniques of radar and reconnaissance by aircraft, and doubtless soon also by satellite, are being developed under the impetus of the National Hurricane Research Project, in which the authors work. It seems a far cry from the days, more than a century ago, when Englishmen took a leading part in the study of tropical storms. It may be said that the Americans have a special interest: each year they suffer a hundred million dollars' worth of damage from hurricanes, a sum equivalent to several times the expenditure on the entire meteorological service of Britain. But similar storms in the Bay of Bengal last October drowned at least

12,000 members of the Commonwealth; there, tropical storms are about as frequent as in the Caribbean, and there it was that Henry Piddington studied them and invented for them the name 'cyclone'. About the same time, the engineer, Major-General William Reid, after arriving in Barbados to restore Government buildings blown down by a hurricane, took the lead in the study of Caribbean storms. In the present book we read that his own, first published in 1838, "is still held in high esteem as a book of reference". Of course, in those days a spirited man, even on his own, might make some impact; to-day it requires a group of men, handling facilities too expensive to be provided by other than Governments. Nevertheless, the facilities exist; Can it be the spirit which is missing?

F. H. LUDLAM

EARTH HISTORY

The Age of the World

Moses to Darwin. By Prof. Francis C. Haber. Pp. xi+303. (Baltimore, Md.: The Johns Hopkins Press; London: Oxford University Press, 1959.) 40s. net.

IN the not very distant past the question of the age of the world was not the sole concern of scientists and naturalists, but one about which theologians, the informed public, and even the uninformed public were deeply concerned. As recently as 1838, the Rev. Baden Powell, Savilian professor of geometry at Oxford, declared that the most inconceivable assertions of the astronomers and chemists were admitted and even applauded, whereas, on the other hand, the geologist was regarded as visionary and presumptuous if he attempted to draw the obvious conclusions from the rocks he studied and to claim that millions of years ago the Earth was governed by the same physical laws as to-day. The reason for this attitude was, of course, that at that time geologists were attempting to establish natural laws that contradicted the account of the Creation given in the book of Genesis, as well as the statement carried by every Bible then (and for many years afterwards) that the date of the Creation was 4004 B.C.

To-day it is accepted as axiomatic that the age of the superficial rocks of the Earth's crust is of the order of several thousand million years, and that living organisms must have existed on the Earth's surface for at least 500 million years, and probably very much longer. Yet, historically speaking, this conception of the length of the geological time-scale is quite recent.

The complete revolution in scientific thought that has led to the unquestioned acceptance of age figures of such magnitude by scientists and laymen alike has seldom formed the subject of special study, but it has now received the examination it deserves by Prof. F. C. Haber, of the University of Florida, in his book *The Age of the World*. The author is a professional historian and, following the modern tendency in studies in the history of science, he deals with his subject as a special aspect of human history. The sub-title of Prof. Haber's book, *Moses to Darwin*, indicates the period that he covers in detail. So far as the Christian world is concerned, this limitation is justified. Once the teaching of Christianity spread, the Mosaic account of the Creation came to be accepted as literally true throughout Christendom, and this belief was not successfully challenged until the nineteenth century. It not only determined lay opinion for centuries but also exerted an inhibiting effect on the development of more rational views by scientists and naturalists.

In the latter half of the seventeenth century, however, and during the eighteenth century, many advances were made by both geology and cosmogony. In this period, the author points out, doubts were expressed from time to time as to the validity of the Mosaic dogma. For example, in 1681, Thomas Burnet, sometime Master of the Charterhouse, published the first volume of his *Sacred Theory of the Earth*, a book very widely read at the time and for many years afterwards. While of little scientific import, it had the merit of conforming to the teachings of the Bible. Yet even Burnet, himself a divine, ventured to suggest in a later book that the Biblical days of the Creation might be considered as allegorical rather than literal days. As a result of this heresy he lost his position at Court. A further instance, not noticed by Prof. Haber, was the publication by the astronomer Halley, in 1715, of a rather cautious suggestion that the Biblical account of the Creation could not be taken literally. Halley also made what was probably the first suggestion of a scientific method for determining the age of the Earth—by measuring the rate of increase of the salinity of the oceans—a method that was actually used some two hundred years later[1].

In 1749 the great French naturalist Buffon published a *Theory of the Earth*[2] in which he expressed unorthodox views about its age. In consequence the Faculty of Theology in the Sorbonne forced him to retract certain statements and to express a belief in the scriptural account of the Creation. In 1788, and again in 1795, the geologist James Hutton published his well-known dictum that in the rocks of the Earth's crust he could find "no vestige of a beginning —no prospect of an end". He was followed in 1802 by Lamarck, who, in his *Hydrogéologie*, emphasized that the geological processes of Nature must have required vast periods of time. His views were not well received at the time, and were soon overshadowed by the more popular doctrine of successive catastrophes advocated by his fellow countryman Cuvier.

These and other occasional expressions of enlightened opinion had no very marked effect on the broad stream of scientific thought at the time they were published. During the first two or three decades of the nineteenth century, however, geology and related sciences rapidly progressed so that the views of geologists about the age of the Earth could no longer be dismissed as entirely imaginative and had to be given serious consideration. The struggle between Church and science which, so far as geology was concerned, had been smouldering for a century or more, now flared up into the open. Not surprisingly, the statement by Hutton had added fuel to the fire, for to have accepted it would have done away entirely with belief in the Mosaic account of the Creation. Geological science had to contend with religious beliefs that had been firmly held for some eighteen centuries and were not to be overthrown easily, more especially since they were held by many, probably most, scientists of repute, some of whom were in Holy Orders themselves. For a time at least

geologists were reluctant to declare, openly and unequivocally, opinions directly contrary to their religious beliefs, and some prominent geologists, notably Buckland in England and Cuvier in France, attempted to reconcile their geological views with these beliefs. A contemporary publisher's advertisement of an English translation of Cuvier's *Discours sur les Révolutions du Globe*, published in 1813, sums up the situation in the following notice: "The Christian may furnish himself, from the publication of a Parisian philosopher, with armour to defend his faith against those writers who have endeavoured to overturn it by objections against the Mosaic account of the Deluge, and the age of the human race"[3]. The tide had turned, however, and more rational views about the age of the Earth gradually gained ground, even though theological opposition persisted for many years.

Two landmarks stand out on the road of progress towards modern views on the subject. One was the publication of Charles Lyell's *Principles of Geology* (1830–33), which, as a clear, logical and well-documented exposition of the new geology, had a profound and lasting effect on geological thought. The second was the appearance, in 1859, of Darwin's *Origin of Species*, which provided a new and compelling reason for extending geological time. Once the doctrine of evolution was accepted as a reality, there remained only one obstacle in the minds of those who were reluctant to abandon completely the Mosaic account of the creation of the world. This was the strongly held belief that man was a special creation. Evidence from other sources, anthropology, archæology, ethnology and philology, had by this time accumulated to an extent that made it unlikely that this belief would survive long in scientific circles. In any event, it did not effect the main issue, that of the length of geological time, which was already widely accepted as being of immense, though uncertain duration, and the long struggle for recognition of this fact was now over.

This, briefly, is the story discussed at length and with an appropriate historical background by Prof. Haber. He also points out how other branches of knowledge gained from the changed ideas about secular time. Thus, it became possible to explain the occurrence of archæological remains of cultures that, apparently, had been at their height at a time when, hitherto, it had been thought the world had not been created; and it was also possible to accept the suggestion of philologists that the development of languages seemed likely to have commenced in times much earlier than the date assigned by Biblical scholars as that of the Creation. Another anomaly done away with was that produced by the astronomical conception that light emanating from distant sources in the universe had been travelling so long that it had, in the view of the astronomers, left its source before the universe was created.

Prof. Haber's book contains five chapters. In the first he discusses especially the ideas about time held since the dawn of the Christian era and shows how, for centuries, no progress was made towards rational thought on the subject, until the breaking of what he calls the "6,000 year time scale" set up by Archbishop Ussher and others. In Chapter 2, entitled "Historicism and the Scientific Revolution", he considers the growth of geological ideas in relation to the development of science as a whole, up to the end of the seventeenth century. He traces the history of ideas about the origin and significance of fossils. From the time of Aristotle the problem had remained unsolved. Although there appears to be little that is new in his account, he justifies his conclusion that "by the end of the seventeenth century the fossil enigma had been brought into the mainstream of European thought about cosmogony". Consideration is also given in this chapter to the contributions to astronomy and cosmogony made by Descartes, Newton and Leibniz, more particularly regarding the conception that the Earth had cooled from a molten mass. This assumption constituted a considerable advance in geological thought and was later used as a means of calculating the age of the Earth.

In Chapter 3 the author deals with the outlook on his subject that developed during the eighteenth century, a period in which the biological sciences came to the fore, and the idea of perfection of design in Nature was developed. This latter conception, however, did not preclude belief in the Mosaic chronology and cosmogony. In this chapter Prof. Haber also discusses the importance of Buffon's contributions to the advancement of natural history, and gives an account of the remarkable series of experiments, little noticed in Britain, which he carried out in an attempt to make a positive estimate of the age of the Earth. Buffon prepared a series of balls of each of the materials of which the Earth is composed, including rocks, minerals and metals, and after raising them to white heat, determined the rate at which they cooled to room temperature. On the assumption that the Earth had once been a molten mass he calculated the duration of several periods in its history, allotting about 40,000 years as the time that had elapsed since the Earth had cooled sufficiently to allow life to exist on its surface. Buffon published a full account of these experiments in 1778, in his *Epoques de la Nature*[4]. Though, by present-day standards, his results are quite unacceptable, they indicate an advance in the thought of that period.

Chapter 4 is entitled "The Biblical Age of the Earth Surrendered", the first part having the subtitle "The Flood Triumphant". At the beginning of the nineteenth century it became evident to geologists in both Europe and America that vast land areas were covered with unconsolidated deposits, sometimes containing mammalian remains, that could easily pass for material left by a retreating flood. This fact was seized on by theologians and many geologists, as proof that a more or less universal Noachian flood had been a reality in the not too distant past. The author goes on to describe what he calls the "Lyellian Revolution", which played a large part in the final overthrow of belief in the Mosaic chronology among scientists. The chapter concludes with an account of "Mosaic Geology in America". In his final chapter the author discusses the effect of the publication of the *Origin of Species* on ideas about geological time; and, lastly, the origin of man.

Among scientists the overthrow of belief in the Biblical chronology of the Creation was now virtually complete, and the only question that remained a live issue was not one of geology versus theology but what, in more precise terms than had as yet been proposed, really was the age of the Earth. During the nineteenth century attempts were made to estimate this in various ways. Prof. Haber does not

enlarge on them, and he makes only a very brief reference to the work of Sir William Thomson (Lord Kelvin), who, shortly after the publication of the *Origin of Species*, attempted to solve the problem by means of astronomical and physical data. The story of his intervention, the concern it caused among biologists, particularly Darwin, and among geologists, too, and the revolutionary effect the discovery of radioactivity had on the resolution of the problem, leading, as it did, to an entirely new method of calculating the Earth's age, is an interesting one. It would have rounded off Prof. Haber's story in a very satisfactory way if he had continued it in rather more detail to the time when the new radioactive methods of determining the age of the Earth were first used, some fifty years ago. This criticism apart, he has written an extremely interesting book, which is not just a record of isolated opinions, events and discoveries but a continuous narrative of the development of ideas on his subject. There is no bibliography, but extensive footnotes provide a valuable guide to source material.

V. A. EYLES

[1] *Phil. Trans. Roy. Soc.*, **29**, 296 (1715).

[2] De Buffon, G. L. L., in *Histoire Naturelle*, **1**, 65 (1749).

[3] The advertisement occurs in a copy of J. J. Berzelius' *Mineralogy*, translated by J. Black, London, 1814, in the possession of the reviewer.

[4] First published as Supplément **5** to Buffon's *Histoire Naturelle* (1778). Preliminary results of the experiments were published in Suppléments **1** and **2** (1774) of the *Histoire Naturelle*.

GEOPHYSICAL METHODS

Methods and Techniques in Geophysics

Vol. 1. Edited by Prof. S. K. Runcorn. Pp. ix + 374. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1960.) 10 dollars; 72*s*.

MANY books and review articles have been written which are concerned with the observational data of geophysics and the deductions from them; Prof. S. K. Runcorn's aim in presenting this book is to provide a comparable account of the methods and techniques which are used to obtain the observations, which will be useful to those who wish to start a particular type of experimental work and to those who wish to evaluate critically the methods and the results.

It contains accounts of the techniques used in a variety of investigations: there are two articles on heat-flow, one by Sir Edward Bullard and the other by A. D. Misener and A. E. Beck; articles on borehole surveying by T. F. Gaskell and P. Threadgold; the geomagnetic elements by K. Whitham; palæomagnetism by D. W. Collinson and K. M. Creer; gravity at sea by J. C. Harrison; earth movements by P. L. Willmore; earth currents by G. D. Garland; the properties of rocks under high pressure and temperature by D. S. Hughes; and the secular motion of the pole by W. Markowitz.

The accounts are good, and admirably fulfil their purpose; obviously, it is not possible to give a complete account of all the experimental techniques involved in every type of measurement, but the general principles and sufficient practical details and difficulties are related, and quite detailed references have been given. The measurement of heat-flow is an important geophysical technique and this has been recognized by two articles on it. Harrison's account of the measurement of gravity at sea includes an account of the cross-coupling effect, and points out that in the case of a beam-gravimeter stabilized along the true vertical the error due to it in an extreme case could be as high as 500 mgals; in actual operation, however, the error with the Graf instrument can be maintained less than 15 mgals and a correction can of course be made for it. The errors involved in gravity at sea are still essentially navigational.

The article on measurements in palæomagnetism shows a curious balance in that so much is concerned with the astatic magnetometer. It might perhaps be argued that the original papers in which the instrument was described are not easy to obtain, and that it is the fundamental instrument used in the study of rock magnetism; nevertheless, it is curious that there is no account of the effects of pressure on the magnetic properties of rocks, or an account of alternating-current bridge methods of measuring susceptibility.

These criticisms are trifling, however; this is an excellent book and is well produced. It is bound to be of use to many geologists and geophysicists.

M. J. KEEN

POLYSACCHARIDES OF MICRO-ORGANISMS

Polysaccharides of Micro-Organisms

By Prof. M. Stacey and Dr. S. A. Barker. Pp. vii + 228 + 8 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1960.) 30*s*. net.

IT was a courageous undertaking on the part of Prof. Stacey and Dr. Barker to attempt to review the extensive field of microbiological polysaccharides in one small volume of more than 200 pages. They have, however, achieved this task, and have produced an elegant little book which is both up to date and readable, and will be much appreciated and enjoyed by those who already have a good grounding in carbohydrate chemistry.

Early in the book there is a short account of carbohydrate nomenclature and conformation, which is followed by a brief description of the various monosaccharide components encountered and their biosynthesis. There follows an account of the structural components of cells, of the function of capsular and cell-wall polysaccharides and of biological activity; and, in an attempt to appeal to the non-specialist reader, the authors have included two chapters in which the older (classical) and modern approaches to the isolation, purification and structural analysis of polysaccharides are given. These chapters are of necessity concise, but are timely in that they emphasize the value and importance of employing the results of physical, chemical and serological measurements to establish the homogeneity, or more correctly, the lack of demonstrable heterogeneity, of the materials under investigation. The establishment of the suitability

of polysaccharide preparations for structural studies is an aspect of polysaccharide chemistry which has been much neglected until recently.

The remaining seven chapters are devoted to the polysaccharides associated with Gram-negative and -positive bacteria, viruses, rickettsiæ, moulds, yeasts, yeast-like fungi and protozoa.

The bacterial heteropolysaccharides have been longest and most thoroughly studied; but, in spite of all the effort since many of these important substances were discovered in the early part of the century, the progress in elucidating their detailed structure and, in some instances, even the qualitative composition, has been disappointingly slow. However, recently there has been a renewed attack on these materials in many different laboratories and already startling results are being obtained, especially in determining the fine structural details which are primarily responsible for the outstanding and characteristic serological specificity of many of the microbial polysaccharides. Indeed, it is the use of enzymic and serological inhibition studies and the more modern techniques of carbohydrate chemistry, such as periodate oxidation, that has enabled so much progress to be made in such important fields as the association of a known chemical structure with the delicate and specific serological reactions as developed in the outstanding Kauffmann-White scheme for *Salmonella* classification. Here the important new work of Westphal and of Staub and their associates is rightly described. It is, however, unfortunate that the closely related and pioneering work of McCarty in this field has been overlooked.

The nature of the dextrans produced by many strains of *Leuconostoc mesenteroides* and closely related organisms is considered in detail, and a very valuable table (17) is included, in which are given the amounts of 1–6, 1–4 or 1–3 glycosidic linkages which may be expected to be present in a particular bacterial dextran.

Little can yet be said about the polysaccharides of rickettsiæ and viruses. The chapter on the polysaccharides of the so-called 'Higher Bacteria', which deals largely with the products derived from human, bovine and avian strains of *Mycobacterium tuberculosis*, makes fascinating reading and contains much useful information. The polysaccharides of moulds have been much studied, but, in many instances, apart from some knowledge of the qualitative composition of the polysaccharides obtained, little or nothing is known of their structure. Similarly, with a few exceptions, the carbohydrate complexes produced by yeasts and protozoa are, as yet, largely uninvestigated.

Two appendixes, one containing the melting points and specific rotations of the monosaccharides most frequently encountered in the polysaccharides considered, and a second giving a brief account of some of the more important papers which have appeared since the manuscript was completed, are most useful additions.

The book is beautifully produced, and the paper, printing and binding are all that could be desired. The formulæ given in the text are well set out and clearly produced, and the selection of those references believed to be of key importance are remarkably complete up to 1958. The book is reasonably priced and the authors and publishers are to be congratulated on producing a short, well-written and up-to-date account of polysaccharides synthesized by micro-organisms.

W. T. J. Morgan

THE GROWTH OF ORGANIC CHEMISTRY

Advances in Organic Chemistry

Methods and Results, Vol. 1. Pp. ix+387. 90*s*. Vol. 2. Pp. vii+504. 113*s*. Edited by Ralph A. Raphael, Edward C. Taylor and Hans Wynberg. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1960.)

"THE subject of organic chemistry exercises a perennial fascination for the scientific publisher." It is with this rather naive admission that the editors introduce the present series and presumably seek to justify its existence. There is no denying the advances in organic chemistry, in methods and results. But is this series really necessary when, in addition to the recognized sources of information, a parallel series covering progress in organic chemistry is already well established and has gained popular acceptance?

Six topics are reviewed in Volume 1. These are: Kolbe electrolytic synthesis (B. C. L. Weedon); polyphosphoric acid as a reagent in organic chemistry (F. Uhlig and H. R. Snyder); the Wittig reaction (S. Trippett); hydroxylation methods (F. D. Gunstone); selective degradation of proteins (E. O. P. Thompson); optical rotatory dispersion and the study of organic structures (W. Klyne). Of these, four have been the subject of reviews elsewhere within the past few years and an authoritative text-book on one of the themes has recently appeared. Still, this new publication may be taken as an indication of the widespread interest in and the vigorous development of the fields in question. Volume 2 certainly strikes a newer note. Here, the editors have been more discriminating in the selection of topics, which include: alkenylmagnesium halides (H. Normant); dialkoxydihydrofurans and diacyloxydihydrofurans as synthetic intermediates (N. Elming); ethynyl ethers and thioethers as synthetic intermediates (J. F. Arens); ketene in organic synthesis (R. N. Lacey); nuclear magnetic resonance in organic structural elucidation (H. Conroy); hydrogenation-dehydrogenation reactions (L. M. Jackman); ultra-violet photochemistry of simple unsaturated systems (P. de Mayo); muscarine (C. H. Eugster).

Normant's review will be warmly welcomed. His discovery that alkenylmagnesium halides are formed in excellent yield by the Grignard reaction when solvents such as tetrahydrofuran are used in place of ether constituted an important advance in preparative organic chemistry. The reaction has been exploited in many directions; it has proved particularly useful in the field of organometallic chemistry. The elegant electrolytic method for the dialkoxylation of furans due to Clauson-Kaas has made available a group of new and versatile intermediates. These dialkoxydihydrofurans and the related diacyloxy derivatives have been widely used for many synthetic purposes. Elming, who has been closely associated with this work, gives an admirable survey. Arens provides an excellent review of the preparation and reactions of ethynyl ethers and thioethers. This is a valuable addition to the literature on acetylene chemistry. Although earlier reviews on certain aspects of ketene chemistry have appeared, Lacy, in his contribution, gives a

unified presentation of the reactions of ketene and its derivatives—diketene, *iso*propenyl acetate and β-propiolactone—compounds which are of considerable industrial importance. Despite the existence of several standard works on the subject, the inclusion of a chapter in this series on the applications of nuclear magnetic resonance in structural elucidation is not surprising; such are the potentialities of this new tool. As the author rightly points out, its intelligent use demands more of an understanding of the principles involved than does any other form of spectroscopy in popular use by organic chemists. However, within this brief compass, the author is only able to deal with those aspects of theory which have direct structural analytical significance. The treatment is concentrated almost exclusively on proton resonance, and solid-state spectra are omitted. Despite these limitations, the review has its obvious merits and will be appreciated by practising organic chemists.

There are occasions when the use of hydrogen-transfer reactions offers striking advantages over catalytic hydrogenation and dehydrogenation and, in consequence, they have their established place in the armoury of the organic chemist. The advantages arising from the usually complete stereospecificity of biochemical hydrogen-transfer reactions had led to some subtle and elegant applications. Jackman's survey of new developments in this field is timely, and many would wish that the section dealing with biochemical systems could have been amplified. Recent years have witnessed a renaissance in photochemistry, and preparative photochemical methods are rapidly gaining favour in certain fields. De Mayo does a signal service by focusing attention on recent developments and suggesting further areas where photochemical processes might prove useful and profitable. Finally, Eugster presents an interesting account of the chemistry of the alkaloid narcarine, the relatively simple, but unique, structure of which has only recently been unravelled, despite the combined endeavours of many illustrious organic chemists over many years.

The series has a truly international flavour, and a very high standard is maintained throughout. The inclusion of some details of experimental procedures adds to the value of the series. If the more individual and original character of the second volume can be maintained in future issues, the series is likely to earn for itself a worthy place on the private book-shelves of many organic chemists as well as in their institutional libraries.

J. Idris Jones

THE PROTON IN CHEMISTRY

The Proton in Chemistry

By R. P. Bell. (The George Fisher Baker Non-resident Lectureship in Chemistry at Cornell University.) Pp. vii+223. (London: Methuen and Co., Ltd., 1959.) 42*s*. net.

IT is perhaps ungenerous to complain that the title of this book is wider than the contents, when the author himself has admitted this in his introduction and made his excuses. The book is, in fact, mainly about the properties of acids and bases, or at least about the transfer of protons from one molecule to another. Within this chosen field, these lectures, given at Cornell University while the author was George Fisher Baker non-resident lecturer, provide a readable, accurate and lucid account of acid-base theory and associated phenomena, and the book can be wholeheartedly recommended to students of physical chemistry as a supplement of their regular texts.

In the final chapter the author has done much to clarify what is known about the isotope effect, that is, the change of properties resulting from the substitution of the proton by the deuteron, in acids and bases.

There are, of course, many other chemical phenomena with which protons are concerned. No doubt some of these would have taken the author too far from the general theme of the book, but some, such as hydrogen bonding, which is only briefly mentioned, might well have been treated at greater length. In view of the great importance of hydrogen bonding in organic and biological compounds, some consideration of the strength of hydrogen bonds would have been welcome.

An account of the present state of knowledge of the structure of liquid water would also have provided a useful background to the properties of the hydronium ion. Another rather surprising omission, since energy curves for proton transfers are given, is any reference to the neutralization of the proton in electrolysis, one of the most direct and simple ways of observing such transfers. It would also probably not be stretching the matter too far to include those redox potentials in which protons are involved.

Another matter of considerable interest, which might well be dealt with in a future edition, might be the circumstances in which a proton, free or hydrated, can capture a free electron and the properties of the hydrogen radical so formed. In view of recent work on the chemisorption of hydrogen at metal surfaces, the polarization of hydrogen atoms and their reactivity, it is not out of the question that this subject might also find a place among the phenomena which might reasonably be included.

It is only necessary to add that the book is very well produced and, under present conditions, reasonably priced.

J. A. V. Butler

SIALIC ACIDS

The Chemistry and Biology of Sialic Acids and Related Substances

By Dr. Alfred Gottschalk. Pp. ix+115+8 plates. (Cambridge: At the University Press, 1960.) 22*s*. 6*d*. net

THIS book deals with a class of naturally occurring substance which has attained great biological importance in the past few years. Although the initial chemical work on the carbohydrate components of mucous secretions was done before the beginning of this century, it was not until about ten years ago that biochemical interest in the mucins of epithelial secretions was awakened by the discovery of their role in blood-group-specific substances and in the inhibition of influenza virus hæmagglutination; Dr. Gottschalk is closely associated with the latter work.

The book starts out with a clear exposition of the historical development of the subject and is followed

by a chapter (28 pages) on the chemistry of sialic acids. A section (25 pages) on the preparation and determination of sialic acids is valuable for its discussion of the advantages and disadvantages of the various methods used. The next two chapters (23 pages) deal with what is to me the most exciting part of the book: the linkage and occurrence of sialic acids in biologically active mucoproteins, mucolipids and other natural products. The following chapter, on the sialic acid content of tissues, usefully collects together scattered data into a readily accessible form. Other chapters deal with enzymes acting on sialic acids and a comparison with bacterial muramic acid.

Minor points are that a structural formula of N-acetyl neuraminic acid would, I think, be helpful on the first page of the historical development, and the section on milk oligosaccharides could well include mention of the work of György and of Malpress.

These are, of course, trifling criticisms of a book which is well written, beautifully produced and, at the price, is good value as an introduction to the sialic acids.

T. F. Slater

TOWARDS PHYSICAL CHEMISTRY AT HIGH TEMPERATURES

Tables of Thermodynamic and Transport Properties of Air, Argon, Carbon Dioxide, Carbon Monoxide, Hydrogen, Nitrogen, Oxygen and Steam

By Joseph Hilsenrath, Charles W. Beckett, William S. Benedict, Lilla Fano, Harold J. Hoge, Joseph F. Masi, Ralph L. Nuttall, Yeram S. Touloukian and Harold W. Woolley. Pp. xiii + 478. (London and New York: Pergamon Press, 1960.) 140*s*. net.

Thermochemistry for Steelmaking

Vol. 1. By Prof. John F. Elliott and Molly Gleiser. (Sponsored by the American Iron and Steel Institute.) Pp. viii + 296. (Reading, Mass.: Addison-Wesley Publishing Company, Inc.; London: Pergamon Press, 1960.) 75*s*. net.

Physicochemical Measurements at High Temperatures

Edited by Dr. J. O'M. Bockris, Dr. J. L. White and Dr. J. D. Mackenzie. Pp. viii + 394. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1959.) 75*s*.; 13.50 dollars.

THE publication of three books serves to emphasize the flow of research and development at present, in regard to systems at high temperatures. Probably the most detailed and most extensive information already within reach concerns the thermodynamic and transport properties of gases. *Tables of Thermodynamic and Transport Properties of Air, Argon, Carbon Dioxide, Carbon Monoxide, Hydrogen, Nitrogen, Oxygen and Steam* presents a valuable compilation of mutually consistent data for temperatures from 10° to 3,000° K. and from 0·01 to 100 atmospheres, for the gases named and for steam and air. Experimental measurements for the various gases were considered to varying degrees in choosing molecular force constants. From the best values, equations of state were derived in the form of virial expansions; a large number of mutually consistent results have been derived from such equations of state. Thermodynamic properties of the ideal gases were derived from spectroscopic data using standard formulæ of statistical thermodynamics. Transport properties were calculated either from empirical data or using force constants based on the Lennard-Jones 6–12 potential. Properties tabulated include (with few exceptions) the compressibility factor, density, entropy, enthalpy, specific heat, specific heat ratio, and velocity of sound, as well as the viscosity, thermal conductivity, and Prandtl number, and vapour pressure of liquid and solid. Other quantities derived for the ideal gases include specific heats, entropies, enthalpies and free energies. In these Tables the only quantities which may still be described as crudely empirical are vapour pressures.

This bold and systematic use of statistical thermodynamics, combined with spectroscopic data and evaluations of molecular force constants, shows very well how the thermal properties of gases at high temperatures can be mastered by the mechanization of thermodynamic calculations. The results are of immediate importance in the conduct of aerodynamic research, and applications to other fields may be predicted with confidence. From these *Tables*, any remaining obstacles to the development of high-temperature thermodynamics of gases seem likely to be overcome without much difficulty. (Librarians should note that these *Tables* were originally published as *U.S. Bur. Stand. Circ.* 564. This edition is a 1960 reprint with revisions. The publishers do not indicate how extensive these are.)

More specialized experimental information required for other fields is by no means available in the same massive way. There has been a need for data at high temperatures in the steel industry for a very long time. One outcome is that much experimental information of use in high-temperature technology is being collected and collated as the result of sponsorship by the American Iron and Steel Institute. *Thermochemistry for Steelmaking* constitutes the first fruits of a large programme of work, and covers a field even wider than steel-making. Physical properties tabulated include density, thermal conductivity, viscosity and surface tension of the liquid state of the elements. Tables are given of standard thermodynamic functions of elements and selected compounds which have been computed up to 3,000° K. Vapour pressures are also given for the more common elements and for selected compounds. Such compilations should prove very valuable in high-temperature chemistry generally, and are likely to stimulate advances not only in steel-making but also in other fields.

The third publication, *Physicochemical Measurements at High Temperatures*, deals with methods of laboratory investigation at high temperatures. In this field the advancement of knowledge must still be described as of uneven quality. Because of their technological implications for extraction metallurgy, certain problems such as the study of chemical equilibria in melts and in slags have received much attention, and considerable mastery has been achieved. A considerable body of fundamental scientific information has also been accumulated through laboratory research on glasses and on refractories. Much still needs to be done, however, to bring the most recent ideas about condensed states of matter to bear on problems which are also of technological importance.

New Books: September 1960–April 1961

In these four pages we are pleased to list recent and forthcoming books. Detailed information on any publication will be sent upon request to either of our offices. Information requested for forthcoming titles will be furnished as soon as it is available.

The Glycolysis and Respiration of Tumors
By ALAN C. AISENBERG
January 1961, 224 pp., illus., 64 s.

Bioenergetics
Consideration of Processes of Absorption, Stabilization, Transfer, and Utilization
Edited by L. AUGENSTINE
September 1960, 685 pp., illus., paper bound, 80 s.

An Introduction to Astrodynamics
By ROBERT M. L. BAKER, JR. *and* MAUD W. MAKEMSON
September 1960, 358 pp., illus., 60 s.

Quantum Theory
Complete in 3 Volumes
Edited by D. R. BATES
Volume 1A, Elements
April 1961, about 450 pp., illus., 80 s.

The Science of Adhesive Joints
By J. J. BIKERMAN
March 1961, 258 pp., illus., 64 s.

Free Radicals in Biological Systems
Edited by M. S. BLOIS
February 1961, 387 pp., illus., 103 s. 6 d.

The Structure and Function of Muscle
Edited by G. H. BOURNE
Volume 3, Pharmacology and Disease
December 1960, 482 pp., illus., 107 s. 6 d.

The Enzymes
Second edition, revised
Complete in 7 volumes
Edited by P. D. BOYER, H. A. LARDY, *and* K. MYRBÄCK
Volume 4, Hydrolytic Cleavage, Part A
October 1960, 631 pp., illus., 128 s. 6 d.
Volume 5, Hydrolytic Cleavage, Part B
March 1961, 645 pp., illus., 143 s.
Special prices on orders for the complete set

The Cell
Biochemistry, Physiology, Morphology
Complete in 5 Volumes
Edited by J. BRACHET *and* A. E. MIRSKY
Volume 4, Specialized Cells, Part 1
December 1960, 511 pp., illus., 128 s. 6 d.
Volume 5, Specialized Cells, Part 2
December 1960, 597 pp., illus., 143 s.
Special prices on orders for the complete set

Digital Computer Design
Its Logic, Circuitry, and Synthesis
By EDWARD L. BRAUN
April 1961, about 630 pp., illus., approx. 107 s. 6 d.

The Chemistry of Lignin
Supplement Volume
Covering the literature from 1949 to 1958
By FRIEDRICH E. BRAUNS *and* DOROTHY A. BRAUNS
December 1960, 804 pp., illus., 128 s. 6 d.

Laboratory Studies in General Chemistry
(with Instructor's Manual)
By FRANK BRESCIA, ADOLPH G. ANDERSON, JOHN G. ARENTS, HERBERT MEISLICH, *and* AMOS TURK
January 1961, 210 pp., illus., 26 s.

Methods of Celestial Mechanics
By DIRK BROUWER *and* GERALD M. CLEMENCE
March 1961, 598 pp., illus.

Field Theory
And the Many-Body Problem
Edited by E. R. CAIANIELLO
Vol. 1, *April 1961, about 325 pp., illus., 76 s.*

The Nucleic Acids
Chemistry and Biology
Edited by ERWIN CHARGAFF *and* J. N. DAVIDSON
Volume 3, *September 1960, 588 pp., illus., 128 s. 6 d.*

Rhythmic Activity in Animal Physiology and Behaviour
By J. CLOUDSLEY-THOMPSON
April 1961, about 250 pp., illus.

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Mineral Metabolism
An Advanced Treatise
Edited by C. L. COMAR *and* FELIX BRONNER
Volume 1, Principles, Processes, and Systems
Part A, *September 1960, 416 pp., illus., 86 s.*
Part B, *March 1961, about 500 pp., illus., 103 s. 6 d.*

Infrared Methods
Principles and Applications
By G. K. T. CONN *and* D. G. AVERY
September 1960, 203 pp., illus., 54 s.

Spaceflight Technology
Edited by KENNETH W. GATLAND
February 1961, 365 pp., illus., 75 s.

Biochemistry of Insects
By D. GILMOUR
February 1961, 343 pp., illus., 64 s.

Metabolic Pathways
Completely Rewritten Second Edition
of Chemical Pathways of Metabolism
Edited by DAVID M. GREENBERG
Volume 1, Carbohydrates, Lipids, and Related Compounds
September 1960, 572 pp., illus., 128 s. 6 d.

The Bacteria
A Treatise on Structure and Function
Complete in 5 Volumes
Edited by I. C. GUNSALUS *and* R. Y. STANIER
Volume 2, Metabolism
April 1961, 572 pp., illus., approx. 115 s.
Special prices on orders for the complete set

Biological Approaches to Cancer Chemotherapy
Edited by R. J. C. HARRIS
March 1961, about 425 pp., illus., 100 s.

Protein Biosynthesis
Edited by R. J. C. HARRIS
April 1961, about 425 pp., illus., approx. 86 s.

Carcinogenesis
By I. HIEGER
February 1961, 138 pp., illus., 40 s.

Diffusion in Solids, Liquids, Gases
Third printing, with addendum
By W. JOST
October 1960, 652 pp., illus., 114 s. 6 d.

Activation Analysis Handbook
By R. C. KOCH
October 1960, 219 pp., 64 s.

Elements of the Theory of Functions and Functional Analysis
By A. N. KOLMOGOROV *and* S. V. FOMIN
Translated from the Russian by NATASCHA ARTIN-BRUNSWICK *and* A. JEFFREY
April 1961, about 150 pp., illus.

Milk: The Mammary Gland and Its Secretion
Edited by S. K. KON *and* A. T. COWIE
Volume 1, *March 1961, 515 pp., illus., 100 s.*
Volume 2, *March 1961, 423 pp., illus., 86 s.*

Physics and Astronomy of the Moon
Edited by ZDENĚK KOPAL
April 1961, about 540 pp., illus., approx. 107 s. 6 d.

Ballistic Missile and Space Technology
Edited by DONALD P. LEGALLEY
Volume 1, Bioastronautics and Electronics and Invited Addresses
January 1961, 494 pp., illus., 72 s.
Volume 2, Propulsion and Auxiliary Power Systems
December 1960, 441 pp., illus., 72 s.
Volume 3, Guidance, Navigation, Tracking, and Space Physics
December 1960, 450 pp., illus., 72 s.
Volume 4, Re-entry and Vehicle Design
1960, 422 pp., illus., 72 s.

Biology and Comparative Physiology of Birds
Edited by A. J. MARSHALL
Volume 1, *October 1960, 518 pp., illus., 100 s.*
Volume 2, *March 1961, 468 pp., illus., 100 s.*

Electrolytic Dissociation
By C. B. MONK
March 1961, 320 pp., illus., 80 s.

Gas Chromatography
Edited by H. J. NOEBELS, N. BRENNER, *and* R. F. WALL
March 1961, 463 pp., illus., 114 s. 6 d.

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X-Ray Analysis of Organic Structures
By S. C. NYBURG
March 1961, 434 pp., illus., 93 s.

Toxic Phosphorus Esters
Chemistry, Metabolism, and Biological Effects
By R. D. O'BRIEN
September 1960, 434 pp., illus., 103 s. 6 d.

Solution of Equations and Systems of Equations
By A. M. OSTROWSKI
October 1960, 202 pp., illus., 54 s.

Biological Activities of Steroids in Relation to Cancer
Edited by GREGORY PINCUS *and* E. VOLLMER
October 1960, 530 pp., illus., 107 s. 6 d.

Interfacial Phenomena
By E. K. RIDEAL *and* J. T. DAVIES
April 1961, about 450 pp., illus.

Water in Relation to Soil and Crops
Reprinted from Advances in Agronomy, Volume 11
By M. B. RUSSELL, *et al.*
November 1960, 131 pp., illus., 32 s.

Oxide Ceramics
Physical Chemstry and Technology
By E. RYSHKEWITCH
September 1960, 472 pp., illus., 114 s. 6 d.

The Structure of the Eye
Edited by GEORGE K. SMELSER
January 1961, 570 pp., illus., 107 s. 6 d.

Toxicology
Mechanisms and Analytical Methods
Complete in 2 Volumes
Edited by C. P. STEWART *and* A. STOLMAN
Volume 1, *October 1960, 774 pp., illus., 157 s.*
Volume 2, *April 1961, about 819 pp., illus.*

Name Reactions in Organic Chemistry
Second Edition
By ALEXANDER R. SURREY
April 1961, about 280 pp., illus.

Concepts from Tensor Analysis and Differential Geometry
By TRACY Y. THOMAS
February 1961, 119 pp., illus., 40 s.

Quantum Mechanics of Many-Body Systems
By D. J. THOULESS
April 1961, about 175 pp., illus.

New Approaches in Cell Biology
Edited by P. M. B. WALKER
December 1960, 218 pp., illus., 48 s.

The Physiology of Crustacea
Edited by T. H. WATERMAN
Volume 2, Sense Organs, Integration, and Behavior
January 1961, 681 pp., illus., 164 s. 6 d.

The Nervous System
An Outline of the Structure and Function of the Human Nervous System and Sense Organs
By G. M. WYBURN
February 1961, 179 pp., illus., 40 s.

SERIAL PUBLICATIONS

Advances in
Agronomy
Edited by A. G. NORMAN
Volume 12, *October 1960, 464 pp., illus., 89 s. 6 d.*

Advances in
Carbohydrate Chemistry
Edited by MELVILLE L. WOLFROM *and* R. STUART TIPSON
Volume 15, *January 1961, 445 pp., illus., 100 s.*

Advances in
Catalysis and Related Subjects
Edited by D. D. ELEY, P. W. SELWOOD, *and* P. B. WEISZ
Volume 12, *September 1960, 324 pp., illus. 88 s.*

Advances in
Electronics and Electron Physics
Edited by L. MARTON
Volume 13, *December 1960, 454 pp., illus., 96 s. 6 d.*

Advances in
Food Research
Edited by C. O. CHICHESTER, E. M. MRAK, *and* G. F. STEWART
Volume 10, *1960, 488 pp., illus., 93 s.*

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Advances in
Protein Chemistry
Edited by C. B. ANFINSEN JR., M. L. ANSON, KENNETH BAILEY, *and* JOHN T. EDSALL
Volume 15, *1960, 447 pp., illus., 93 s.*

Advances in
Veterinary Science
Edited by C. A. BRANDLY *and* E. L. JUNGHERR
Volume 6, *1960, 382 pp., illus., 86 s.*

Advances in
Virus Research
Edited by KENNETH M. SMITH *and* MAX A. LAUFFER
Volume 7, *1960, 400 pp., illus., 80 s.*

The Harvey Lectures
Series 55, *January 1961, 257 pp., illus., 64 s.*

International Review of
Cytology
Edited by G. H. BOURNE *and* J. F. DANIELLI
Volume 9, *September 1960, 424 pp., illus., 93 s.*
Volume 10, *1960, 409 pp., illus., 93 s.*

International Review of
Tropical Medicine
Edited by DAVID R. LINCICOME
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Edited by HENRY H. HAUSNER
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November 1960, 692 pp., illus., 52 s.
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Editor-in-chief; DAVID SELIGSON
Volume 3, *January 1961, 230 pp., illus., 52 s.*

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Volume 18, *March 1961, 615 pp., illus., 107 s. 6 d.*

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Volume 2, *1961, 107 s. 6 d.*

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Volume 1, *1961, 128 s. 6 d.*

Journal of Methematical Analysis and Applications
Edited by RICHARD BELLMAN
Volume 1, *1960, 114 s. 6 d.*
Volume 2-3, *1961, each 114 s. 6 d.*

Journal of Theoretical Biology
An International Journal
Edited by J. F. DANIELLI
Volume 1, *1961, 121 s. 6 d.*

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The plan of the book is to present a collection of articles by various experts concerned predominantly with solids and melts. Only brief reference is made to flames or gases at high temperatures. It is to be regretted that the interaction between gases and condensed states of matter is not dealt with. Such interaction is the origin of many difficulties in making measurements at high temperatures, and its study is of great practical as well as theoretical interest.

In its chosen fields, this book is a useful guide to techniques of research at high temperatures. It contains chapters on temperature measurement and control, on refractory materials, on various equilibria, and on applications of calorimetry, densitometry and viscosity. Measurements are described on surface tension, on vapour pressures, on light scattering, on ultrasonic velocities, on diffusivity, and on various electrochemical parameters. Probably unavoidably at the present stage of high-temperature studies, individual sections of this text differ considerably in critical quality. Some of the authors attempt to survey the field in perspective, and to arrive at conclusions, however provisional, that may at least guide new entrants into the field. Others tend to provide catalogues of work at high temperatures, without much discriminating comment.

Physico-chemical properties have generally been studied at high temperatures only because of some compelling technological requirement, or because new opportunities for making fundamental measurements have become available by the development of new techniques not too difficult for laboratories of general physical chemistry. Further progress in the very important field of high temperatures depends on both kinds of research stimuli. It can be argued that the development of research at high temperatures on an adequate scale in Britain awaits the provision of more specialized research laboratories with really adequate resources, closely allied with technological development projects. However this may be, the publication of books such as the present triad offers valuable help in mastering present achievements and in planning for the future. A. R. UBBELOHDE

UNNATURAL PRODUCTS

Silicones

By R. N. Meals and F. M. Lewis. (Reinhold Plastics Applications Series.) Pp. xi+267. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1959.) 48s. net.

Organosilicon Compounds

By Dr. C. Eaborn. Pp. x+530. (London: Butterworths Scientific Publications, 1960.) 80s.

Unnatural Products

New and Useful Materials from Silicon. By Prof. Eugene G. Rochow. (Thirty-fourth Annual Priestley Lectures.) Pp. vii+117. (University Park, Pennsylvania: Phi Lambda Upsilon, Pennsylvania State University, 1960.) 2.75 dollars.

TWENTY years ago, organo-silicon chemistry would have been identified largely with Kipping's monumental life-work. Since then there has been an enormous accretion of new knowledge, partly because of a general broadening in the scope of organic chemistry, but largely stimulated by the development of silicone polymers and novel methods of synthesis. These three books are all concerned with the chemistry and technology of organo-silicon compounds, but they present it from three quite diverse points of view and for different circles of readers.

Meals and Lewis set out to provide a readable and self-contained account of the silicones for those whose primary interest lies in the silicone oils and resins as technological materials: engineers, chemists in industry and students of technology. The essentials of silicone chemistry and the structural basis of the useful properties of the polysiloxanes are concisely set out; about half the book is devoted to the manufacture of the monomers, the fabrication of materials such as resins and rubbers, based on the silicone polymers, and typical applications of these materials in industry. Due attention is given throughout the book to the properties that confer or limit their usefulness and, within its clearly visualized terms of reference, the book contains a great deal of information.

Dr. Eaborn's book, by contrast, is very definitely written for the research chemist with academic leanings, and he deliberately—and rightly—cuts down to the bare minimum his account of the application of alkyl silicon halides and their derivatives. He has produced an authoritative and comprehensive account of the organic chemistry of silicon (as at late 1958), which will serve as the standard work of reference for all who are interested, as active workers or as teachers of organic (and inorganic) chemistry, in this and cognate fields. To keep the subject within bounds, he imposed some restrictions on his work—the omission of most technical aspects and a self-denying omission (which many readers will regret) of comparisons between organo-silicon chemistry and the organic chemistry of other elements. A commendable feature of the book is the way the author has introduced order into the great mass of factual material by means of three rather general chapters, together making up about a third of the book, and dealing respectively with methods of forming silicon-carbon bonds, bond properties (stereochemistry, bond character and the mechanism of substitution reactions) and the characteristic reactions of silicon–carbon bonds in different molecular environments. A great deal of information, with the relevant references, is summarized here in tabular form.

Much of the fascination of silicon chemistry lies in the analogy that may be drawn with carbon, and the extent to which carbon is really unique. Eaborn emphasizes particularly that the essential difference between carbon and silicon lies in the availability of 3*d* orbitals; this has several far-reaching effects in the chemistry of silicon. It confers a considerable amount of double-bond character on bonds formed between silicon and the halogens, nitrogen and other elements; it enables silicon to attain a five- or six-co-ordinate state in stable compounds or in transient reaction intermediates; it influences profoundly the reaction path in substitution reactions at the silicon atom. The critical way in which these physical-organic concepts are developed will make these general chapters profitable reading for many chemists who are not directly concerned with the remainder of the book. This reviews systematically the formation, structure and properties

of the main classes of organo-silicon compounds—halides, hydrides, oxygen compounds of different types, cyclic compounds, etc. The disparities in length between chapters may perhaps reflect the extent to which some classes of derivative are ripe for investigation. Ample use is made, throughout, of the general concepts developed in the first part, though the organization of the material largely follows the traditional organic chemist's approach. Every chapter is followed by the appropriate bibliography, and the total coverage of the literature is very extensive indeed.

If the first two books are devoted principally to facts, *Unnatural Products*, which embodies Dr. Rochow's Priestley Lectures before Pennsylvania State University, is concerned with ideas. In it he lets his ideas range widely, and develops a theme that he stated briefly in his foreword to the book by Meals and Lewis. In brief, the abundance of silicon in the universe is the direct consequence of its nuclear structure; the chemistry is determined by its electronic structure. The very abundance of silicon challenges technological man to explore and exploit the differences between the familiar compounds of carbon and substances, having no counterpart in Nature, based on the chemistry of silicon. Only by extending our chemical knowledge, so as to make kinetically possible the sort of reaction paths that look attractive thermodynamically, will it be feasible to make the best use of the world's resources of raw materials and energy. In his lectures, Rochow ranged over the modern inorganic chemist's approach to his subject, embracing everything from classical descriptive chemistry, through thermodynamics, to molecular spectroscopy. The lectures afforded an unusual opportunity for a distinguished chemist to show how he thinks about his work. The result (except for one lecture on intramolecular motions and energy barriers, which must have made singularly hard going for his audience) is a very readable little book.

J. S. Anderson

TRILOGY OF CHEMISTRY

Inorganic Chemistry

An Intermediate Text. By C. W. Wood and Dr. A. K. Holliday. Pp. viii+393.

Organic Chemistry

An Introductory Text. By C. W. Wood and Dr. A. K. Holliday. Pp. xxii+321.

Physical Chemistry

An Intermediate Text. By C. W. Wood and Dr. A. K. Holliday. Pp. viii+322.

(London: Butterworth and Co. (Publishers), Ltd., 1960.) 21*s.* each.

THESE three attractively produced books form a series intended to meet the chemistry requirements at Advanced and Scholarship levels of the General Certificate of Education of the various examining boards. They should be useful also to first-year undergraduates (not only those reading for a degree in chemistry) and to students preparing for Higher National Certificate, graduateship of the Royal Institute of Chemistry, etc., in colleges of technology.

The authors give no hint of a later volume to cover the concomitant practical work (qualitative and volumetric analysis, typical preparations, etc.), but these already published give concise qualitative tests for each element, and précis the chief organic preparations.

It may be said at once that the volumes more than cover their field, yet not so amply as to make them intimidating to the good advanced-level student. Their large pages and carefully considered typographical plan make them easy to read and to refer to: diagrams, though on the small side and drawn in 'stencil' fashion, are sufficiently clear. Equations are prominently displayed, mainly in structural form in the organic volume, and ionically, where appropriate, in the inorganic.

Each volume is complete in itself: thus, physical chemistry topics, atomic structure and valency, etc., are fully treated in the physical volume, but enough of each is carried into the others to illuminate discussions there. The historical approach is pleasing, without ever becoming oppressive. Much information of interest to the keen student, and not otherwise accessible save by very wide reading, is to be gleaned from the footnotes. The up-to-date treatment may be judged by the adoption of C=12 as the basis for atomic weights: few school text-books have reached this yet.

Misprints are negligible, though the close formulation of ions as, for example, SO_4^{--} and $N_2H_4^{++}Cl_2^-$, instead of in the more open standard form, is rather irritating.

Collaboration between an experienced schoolmaster and a university lecturer seems most effective for work at this 'frontier' level. My own preference is for the physical volume; I feel some slight regret that the authors did not take this opportunity to develop in print the simple approach to organic chemistry recommended by Sir Robert Robinson in a presidential address to the Science Masters' Association about eight years ago, which many of us have found by experience to be more easily assimilable than the wholly systematic impact.

Charles Holt

TREATISE ON ANALYTICAL CHEMISTRY

Treatise on Analytical Chemistry

A Comprehensive Account in Three Parts. Edited by I. M. Kolthoff and Philip J. Elving, assisted by Ernest B. Sandell. Part I: Theory and Practice. Vol. 1. Pp. xxvi+809. (New York: Interscience Encyclopedia, Inc., 1959. Distributed by Interscience Publishers, Inc., New York; and Interscience Publishers, Ltd., London.) 133*s.*

THIS *Treatise on Analytical Chemistry* is to be a major work extending to many volumes. Part I, which is to consist of eight or nine volumes, is devoted to theory and practice. Part II, the analytical chemistry of the elements, will deal extensively with organic as well as inorganic analysis in a series comprising some ten volumes. Part III, which is as yet not fully planned, will be concerned with the analyses of industrial products. The first volume of this last part will be divided into two sections, one dealing with the philosophy relating to the significance and organization of analytical chemistry and the other with specifications and standards;

subsequent volumes of Part III will describe analytical procedures associated with plastics, fabrics, fine chemicals, etc. The final volume of each of the three parts will contain an index for all volumes in that part. There is no index in individual volumes.

The senior editor, Prof. Kolthoff, is noted for his pioneer work on the systematization of analytical procedures and for his ability, both as an investigator and a teacher, to interpret analytical processes on a sound physico-chemical basis. Many of the authors contributing to this first volume are his co-workers and former pupils, and the continuity of his influence can be observed clearly throughout these pages. The approach of the seventeen authors of these first nineteen chapters is remarkable for its uniformly high standard. The clear descriptions of essentials and fine details are outstanding.

The subject-matter of this volume may be listed briefly as follows: methods of analytical chemistry; errors, their detection, determination and control; evaluation and interpretation of accuracy and precision; sampling, rationale and techniques; elements and compounds, an account of modern atomic and molecular theories; atomic weights; thermodynamics of chemical equilibria; graphical presentation of data; electrode potentials; concept and determination of pH; acid-base theories; acid-base strength and aqueous titration curves; non-aqueous acid-base titrimetry; complexometry; mechanism of redox titrations; redox equilibria; solubility; precipitation; equilibrium in precipitation reactions.

Thus this volume is chiefly concerned with the basic principles of analysis and more particularly with classical analytical chemistry. But this is not just old material in a new guise, for a fresh approach to the topic is made in almost every chapter. For example, the reader might justifiably expect a conventional treatment of the theory of acid-base titrations, but much new material is to be found in both chapters devoted to this subject.

It is perhaps not entirely fair to single out individual sections for praise, but a special commendation might be given to the chapters on solution and precipitation phenomena, which constitute a lucid account of modern theory written with a strong analytical bias.

To sum up, this volume is a notable beginning to a monumental work which, if the present standard is maintained, will become the standard reference-book of analytical chemistry.

R. BELCHER

A HISTORY OF PLATINUM

A History of Platinum from the Earliest Times to the Eighteen-Eighties

By Donald McDonald. Pp. x+254. (London: Johnson, Matthey and Co., Ltd., 1960.) 35*s*.

FOR many years the author of this fascinating book has been investigating the history of platinum and its associated metals, and speaks with unrivalled knowledge and authority. The result is a most important study which, within the boundaries which Mr. McDonald has set himself, must remain for very many years at least the final statement of fact. In his own words: "the story recounted is that seen by the refiner and fabricator engaged in commerce. It does not concern itself with the recondite parts of the geology of the deposits, nor with the abstruse chemistry which has grown up round the complex series of compounds into which the platinum metals enter so freely. . . . The account is remarkable in its continuity and slow development over the best part of two hundred years and it has never before been told as a continuous tale". The present volume carries the story down to 1880–1890, before which time "the work on the metal was of a fundamental nature and was largely conducted by scientists who published their results. The few people who were tempted into manufacture were either scientists like Wollaston and Deville, who sooner or later published, or they were people like Chabaneau and Bréant, whose secrets eventually leaked out. The facts therefore are available to the historian". To me this would appear to be a remarkable under-statement of the author's task, the whole book bearing the marks of long-continued and most pertinacious research.

"After the period of 1880–1890 the position is very different. By then the platinum industry, at any rate as far as Europe is concerned, had moved out of the laboratories of the scientists into the factories of industrialists working in competition with each other." This competition resulted somewhat naturally in great reluctance to publish details of their processes, and the facts have either never been recorded or, if recorded, have since been lost.

Of the ancient civilizations the only one from which undoubted finds of platinum occur appears to be the Egyptian, whither it had found its way mixed with gold imported from Ethiopia where platinum is known to occur even to this day. A seventh-century B.C. box from Thebes with 'silver' characters on one side was sent to Berthelot, who demonstrated beyond doubt that one of these characters consisted of native platinum alloyed with small amounts of gold and iridium. No evidence was found that the Egyptian craftsmen had noticed any difference between this piece of metal and the silver used for the other characters; it had been hammered out in the same way as the rest, and its occurrence was in all probability purely fortuitous.

Other references from Roman times onwards which have been suggested as applying to platinum are of doubtful applicability, and in the author's opinion "there seems no doubt that the platinum which about the middle of the eighteenth century began to reach Europe from the Spanish Colonies in South America was the first to be recovered in any quantity and the first to attract the scientific curiosity of mankind". The story of the discovery and exploitation of the metal there is told in great detail from the time that the Spanish colonists threw it away as a nuisance in their search for gold, though a few samples were sent back to Spain. The earliest known rumour of its existence based on some solid foundation occurs in the writings of della Scala (1484–1558), an Italian scholar and poet, but how unimportant the metal was considered is shown by the fact that the first mention of it in European literature appears to be a book published in Madrid in 1746. From then onwards the list of scientists who became interested contains the names of almost everyone of renown: Lavoisier and Bergman, Faraday and Wollaston, Wohler, Berzelius and

very many others, and more than half the book is devoted to this section of the history; not merely the history of platinum, it amounts almost to a history of contemporary science.

The author's long association with the firm of Johnson, Matthey and Co., Ltd., to which more than to any other body the commercial development of this and its allied metals is due, has enabled him to use records which have proved invaluable in the elucidation of the later stages of his work. Percival Norton Johnson—of whom Mr. McDonald has already published an outstanding biography—published an account of work on the separation of gold and platinum in 1812 and from then, until he retired in 1860, he and his partners played a major part in both the scientific as well as the industrial evolution of the platinum metals.

Mr. McDonald has presented his story in a most scholarly yet delightful and readable form, and his firm has published a volume which it is a pleasure to read, and which constitutes an outstanding contribution to the history of the precious metals.

F. C. Thompson

THE ADVANCE OF FLUID MECHANICS

The Scientific Papers of Sir Geoffrey Ingram Taylor

Edited by Dr. G. K. Batchelor. Vol. 2: Meteorology, Oceanography and Turbulent Flow. Pp. x+515. (Cambridge: At the University Press, 1960.) 75*s*. net.

THE second of four volumes of Sir Geoffrey Taylor's collected works has now appeared, and we gasp at the achievement represented by this one volume only. Its fields, of meteorology, oceanography and turbulent flow, are in fact almost one, for the main theme is turbulence, whether in the atmosphere, the oceans or in the laboratory, and whatever the medium discussed, the growth of ideas is essentially continuous. Of the 45 papers presented, however, some five or six deal with gravity waves in fluids and these have their own special appeal.

Theoretical work on atmospheric turbulence began with Taylor's classical *Philosophical Transactions* paper of 1915, "Eddy Motion in the Atmosphere", in which he invented the 'mixing length' concept of turbulent exchange and applied it to the thermal and moisture modifications of air masses and the distribution of wind in the terrestrial boundary layer. Moreover, he was able to put flesh on to the bones of his theory from observations he had taken only a year or so earlier from the ice-scout ship *Scotia* and, in so doing, established a way of working which always kept theory and observation reacting closely on each other. In fact, there is about one paper only on turbulence in this volume which is not in some sense immediately framed by observation. That is the famous 1921 paper, "Diffusion by Continuous Movements", in which the mixing length concept was generalized in terms of the Lagrangian autocorrelation function and a notable relation between certain statistical properties of a turbulent field was first stated. The development of this approach was, however, hindered by lack of observations on the statistical properties treated, and from 1921 until 1935 the pace of Taylor's original work on turbulence slackened somewhat; though this period contained the very thoughtful work on the difference between momentum transfer, in which pressure forces are concerned, and the transfer of inert 'substance' such as heat (in some circumstances) and matter. Then, during 1935–36, came the great surge, the beginning of the modern era, with the "Statistical Theory of Turbulence", Parts 1–5, growing out of the 1921 paper, but now testable because of the introduction of more readily observed Eulerian statistics and because of advances in observational techniques, particularly the hot-wire anemometer, over the previous few years. The strength of this work largely derives from the results which Taylor was able to deduce when the turbulence is isotropic and essentially dissipative: it left the structure and behaviour of the large, energy-containing and transferring eddies mainly as a subject for further inquiry and that remains more or less true to-day. In this connexion it is of interest that the penultimate paper, of 1956, deals in a sense with one aspect of the latter problem, the behaviour of large eddies, produced by buoyancy, in a stably stratified fluid.

The other work in this volume, on gravity waves, has a special contemporary interest in our present age of 'big bangs'. In 1929 Taylor showed that the travel of the pressure wave from the Krakatoa eruption would not support the thesis, deriving from Kelvin, that the marked semi-diurnal variation of pressure in the atmosphere could be ascribed to resonance with the 12-hour tidal force. But he later showed that the atmosphere might have free periods other than that associated with the Krakatoa wave, and he suggested that these might arise from the complex thermal structure of the upper atmosphere. That, as Pekeris, and Weekes and Wilkes later showed, was in fact the case, and tidal resonance was 'saved'. But the theory of the semi-diurnal variation of pressure is not, on that account, complete.

This volume is to be prized on a number of counts: not least, of course, as a record of the growth of ideas, but more, I believe, as providing the possibility of finding out how the record has been achieved, and, perhaps, of doing likewise. There is only one Sir Geoffrey Taylor, but his recipe for cooking could mightily help a good young chef if he will read the recipe carefully enough. To any with the love of the tantalizing study of fluid motion it will bring enjoyment and enrichment, and a new knowledge of the art of science.

P. A. Sheppard

REVIEWS OF NUCLEAR PHYSICS

Progress in Nuclear Physics

Vol. 8. Edited by Prof. O. R. Frisch. Pp. vii+304. (London and New York: Pergamon Press, 1960.) 90*s*. net.

THE latest volume in Prof. O. R. Frisch's review series contains six articles, three written by experimentalists and three by theoreticians. The subjects embrace cosmic rays, high-energy nuclear physics (well represented this time in both its theoretical and experimental aspects), and low-energy physics, where the emphasis is on nuclear models and theoretical interpretation. As in previous volumes in this series, the articles are all of a high standard in their primary function of collating and

discussing critically the relevant published work on their particular subjects. Most of them are also commendable for their clarity of presentation and their provision for readers not already experts in the specific fields.

In the first article, "The Composition of the Primary Cosmic Radiation", C. J. Waddington presents a masterly and clear discussion of the present data on fluxes and the charge and energy spectra of light and heavy nuclei in the primary cosmic radiation. From the sometimes conflicting information available, he extracts a table summarizing what appear to be the present best flux-values, and points out the interest and importance of future work with balloon- and satellite-borne equipment.

"The Interaction of Polarized Nucleons with Nuclei" is treated by E. J. Squires, who considers the various theoretical approaches which have been made to the interpretation of polarization data. The approximations involved in deriving the theoretical formulæ are discussed, and the limitations which they impose are pointed out. Squires's treatment, which is thorough and includes copious references, is intended primarily for the specialist and may be found somewhat heavy going by readers inexperienced in this field.

"Collective Motion in Nuclei" by D. M. Brink is a survey of the present status of the rotational, vibrational, and unified nuclear models. The author first summarizes the essentials of the subject as covered in previous reviews. He then goes on to discuss in somewhat greater detail more recent advances, particularly particle coupling schemes and the attempts which are being made to justify the models theoretically.

"Dispersion Relations for Elementary Particles" by J. Hamilton is food for theoretical physicists. It is, moreover, an excellently constructed review article, presenting the subject in an interesting and lucid fashion. The introduction shows clearly what a dispersion relation looks like and its uses in simple examples. There is a brief but instructive section explaining the importance and scope of dispersion relations as a technique for studying the properties and interactions of elementary particles. Then follows the main substance of the article, in which a variety of scattering and related problems are ably discussed.

In "Cherenkov Detectors" G. W. Hutchinson gives a clear and up-to-date review of recent developments in these detectors as applied to the physics of high-energy machines. The main emphasis is on progress which has been made since the appearance of previous reviews on the subject. Particularly valuable are the accounts of various forms of the gas counter and of the solid–liquid critical reflexion counter. Total absorption counters are discussed briefly; there is very little mention of cosmic-ray applications.

In the final contribution, on "The Photoproduction of Pions", E. H. Bellamy describes the experimental techniques used for investigating the production of charged and neutral pions by high-energy photons, and surveys the data at present available on cross-sections and angular distributions. In a series of useful diagrams the data are summarized and compared with theoretical curves. However, some sections, particularly in the first half of the article, are not very clearly presented.

JOAN M. FREEMAN

A FEW NUCLEONS

Nuclear Forces and the Few-Nucleon Problem

Proceedings of the International Conference held at the Physics Department, University College, London, 8–11 July, 1959. Edited by T. C. Griffith and E. A. Power. Vol. 1: Pp. xiii+1–340. Vol. 2: Pp. vii+341–712. (London and New York: Pergamon Press, 1960.) 200*s*. per set of two volumes.

A GOOD way to stimulate activity in a particular field of research is to hold an international conference. Such a conference was held in July 1959, at University College, London, to discuss the nuclear few-body problem (reported briefly in *Nature*, **184**, 1113; 1959). The two volumes under review are the official Proceedings.

The difficulty in understanding systems of a few nucleons is mainly mathematical; it is very hard to calculate their properties reliably from given nuclear forces, or to learn about the latter from the former. Except in the two-nucleon system, there are too many independent variables for comfort and yet too few to justify taking averages (as in the many-body problem). The conference produced no spectacular solution, but it directed attention to the problem, summarized the present situation and indicated some lines for further research.

The conference began with the two-nucleon problem and what has been learned about the basic two-body forces. This occupies a quarter of the Proceedings: rather a large share, but a fair indication of where most progress has been made. Next came high-energy scattering of nucleons from light nuclei, much of which can be reduced approximately to two-body interactions, and a session on photonuclear reactions. The conference then reached the core of the few-nucleon problem: binding energies and low-energy scattering and reactions, involving three to eight nucleons. Here the true difficulties emerged and all manner of approximations were used to overcome them. Some of the latter look rather crude to an outsider, but clearly solutions which are anything like exact are not feasible. The full calculations are too much for present fast electronic computers; a relatively simple example was estimated to need several hundred hours on an I.B.M. 704 computer. Of course, as a man from Los Alamos remarked, it depends on how many 704's you have. The conference finally ended on the border of the many-body problem, with systems of up to sixteen nucleons.

Each topic was introduced by a review paper, followed by more specialized papers and periods of discussion (the last have been edited for brevity). Altogether there are about ten reviews and seventy other contributions, divided between theory and experiment in the ratio of two to one. The authors include such names as Blatt, Breit, Brueckner, Chew, Marshak, Massey and many other well-known physicists. The Proceedings are thus an authoritative document. They are also much more readable than the learned journals; the style is often that of the spoken word, and most speakers come quickly and concisely to the point. The discussion provides a stimulating commentary on the main text, raising fresh questions and points of view, and bringing some touches of humour. The volumes are handsomely produced, the layout is clear and the errors commendably few. All this is in their favour.

On the other hand, there is inevitably some confusion of notation: the first six authors to write the two-nucleon scattering matrix do so in six different ways. More regrettable, however, is the lapse of some seventeen months before these Proceedings appeared, especially since this kind of literature declines rapidly in value with time. Through special efforts, other conference proceedings have appeared within six months or even—a recent spectacular case—in two. Nevertheless, these volumes retain considerable value and will be read with interest by many physicists.

R. J. N. PHILLIPS

A PANORAMA OF SCIENCE

The Neutron Story

By Dr. Donald J. Hughes. (The Science Study Series, Book 1.) Pp. 158. (London: William Heinemann, Ltd., 1960.) 4*s*. 6*d*.

Magnets

The Education of a Physicist. By Prof. Francis Bitter. (The Science Study Series, Book 2.) Pp. 155. (London: William Heinemann, Ltd., 1960.) 4*s*. 6*d*.

Soap Bubbles and the Forces which Mould Them

By C. V. Boys. (The Science Study Series, Book 3.) Pp. 156. (London: William Heinemann, Ltd., 1960.) 4*s*. 6*d*.

Echoes of Bats and Man

By Prof. Donald R. Griffin. (The Science Study Series, Book 4.) Pp. 156. (London: William Heinemann, Ltd., 1960.) 4*s*. 6*d*.

How Old is the Earth?

By Dr. Patrick M. Hurley. (The Science Study Series, Book 5.) Pp. 160+8 plates. (London: William Heinemann, Ltd., 1960.) 4*s*. 6*d*.

The Wider Universe

By Paul Couderc. (Arrow Science Series.) Pp. 128+4 plates. (London: Arrow Books, Ltd., 1960.) Bound, 10*s*. 6*d*.; Paper, 5*s*.

Matter and Antimatter

By Maurice Duquesne. (Arrow Science Series.) Pp. 127+4 plates. (London: Arrow Books, Ltd., 1960.) Bound, 10*s*. 6*d*.; Paper, 5*s*.

Intelligence

Its Evolution and Forms. By Prof. Gaston Viaud. (Arrow Science Series.) Pp. 127 + 4 plates. (London: Arrow Books, Ltd., 1960.) Bound, 10*s*. 6*d*; Paper, 5*s*.

The Anatomy of Plants

By Prof. P. Font Quer. (Arrow Science Series.) Pp. 128. (London: Arrow Books, Ltd., 1960.) Bound, 10*s*. 6*d*.; Paper, 5*s*.

TO deal with nine volumes at a time may seem more like a march-past than a review. The essential qualitative information can even be dealt with smartly at the double; they are all good, some distinguished, and one a revered classic. One group was written in the United States to serve a specific purpose, at a certain level in schools, as part of a planned programme of physics teaching; I do not know of anything comparable of English origin at present, and regard this as a very valuable series. For the other group, it does seem fair to ask whether we need have gone so far afield, and whether translation in any case is worth while, at least from French; but this also is the start of a series, of which the later members are to be written by the British authors.

The five volumes of the Science Study Series published by Heinemann are the first transplantations of the readers sponsored by the Physical Science Study Committee in the United States. This enterprise, backed by high-level scientists, imagination—and funds—has been conducting a major operation in vitalizing the teaching of physics, and the provision of background reading to supplement the formal course is one of its many sides. These books are intended to be read by very intelligent pupils of about seventeen, and in relation to sixth-form pupils in Britain, it must be said at once that they will not help anyone to get 65 per cent at Advanced level. But they will convey an appreciation of the ideas and methods of science, and a sense of contact with first-rate scientists who have tried to communicate their enthusiasm as well. The difference between them and, say, the excellent books that Pelicans provide is in the type of reader foreseen.

The Neutron Story, by the late Donald Hughes, deals with the discovery of the neutron, its properties and uses, the problems of its decay, and nuclear power. Francis Bitter's book is an introspective account of how the concepts of magnetism take root in a person's mind; he mentions that his interest in science was first aroused by a course in celestial mechanics, an opening gambit which the Ministry of Education's recent Pamphlet 38 would endorse. He reminisces of his work at Cambridge with Kapitza, and of war-time degaussing, and goes on to explain the principles of the work at Massachusetts Institute of Technology on nuclear magnetic resonance. Boys's *Soap Bubbles* is a welcome reprint of a masterpiece; and very timely now that we can get liquid detergents that will supplant the elaborate recipe with Price's glycerin and Castile soap. Griffin's *Echoes of Bats and Men* is a simplified version of *Listening in the Dark*, and is the easiest of the batch to read. I have done some consumer research on Hurley's book, which I used for half a term as the backbone of work with a non-science sixth form; we found it rather difficult, chiefly because I was trying to explain radioactivity concurrently instead of doing this first. But it did its job well, stimulated participation, and as it concentrates on a single problem and its pursuit, gives an excellent example of the way in which scientific ideas develop. I shall do this again, and can recommend it. For the rest, I would make them available for sixth-form pupils to read; so far, nothing else quite at this level and price seems to be published in Britain.

The Arrow Series are translations, three from France and one from Spain. Couderc's *The Wider Universe* is a very good survey of recent progress in astronomy, leading up to the modern theories of cosmology. Duquesne's *Matter and Antimatter* is less satisfying, chiefly because the early chapters deal with familiar work which is in all the text-books, and the discussion of anti-particles (up to 1956) seems a sort of tail-piece. Gaston Viaud's *Intelligence* is an experimental psychologist's approach to the development of conceptual thought, and the processes behind the analytical technique for breaking down an apparently insuperable problem into lesser and manageable units; I found it clear, stimulating and

enjoyable. Font Quer's *The Anatomy of Plants* really scarcely belongs to the group, for it is, in fact, part of the section on morphology from a major work; it is well illustrated, and one's only criticism is that the examples chosen seem to include many plants that are common in Spain but unfamiliar in Britain.

These four books, though probably breaking no new ground in the paper-back field (except by offering a non-paper-back edition as well) are sufficiently distinctive to be recommended for a library as a group; with a special recommendation for Couderc and Viaud.

G. R. NOAKES

PLASMA PHYSICS

Plasma Physics

By S. Chandrasekhar. Pp. 217. (Chicago: University of Chicago Press; London: Cambridge University Press, 1960.) 14*s*. net.

DURING the past few years there has been growing interest in the dynamics of fully ionized gases, much of it stimulated by the hope of releasing energy by the controlled thermonuclear fusion of light elements. Although the classified research in this field was released at the Second Geneva Conference on the Peaceful Uses of Atomic Energy, there is a serious shortage of comprehensive reviews of recent developments, which this collection of Prof. Chandrasekhar's lectures will do much to alleviate. The lecture course was chiefly concerned with the most interesting approach to plasma dynamics—one that lies between a detailed consideration of individual particle orbits, a method which is usable in only the simplest geometries, and the crude but widely applied magnetohydrodynamic method in which the plasma is represented as an electrically conducting fluid. The method is valid for a diffuse plasma in a strong magnetic field and is based on the assumption that the Larmor radius of a typical particle orbit is much smaller than any other length in the problem, and the corresponding gyrofrequency is much greater than any other frequency, including the molecular collision frequency. It is then possible to use a perturbation treatment of particle orbits and make use of a number of adiabatic invariants to simplify the self-consistency problem for the macroscopic fields.

Chandrasekhar's lectures begin with a brief review of the Maxwell–Lorentz theory of the interaction of an assembly of charges with an electromagnetic field, then proceed to a discussion of the orbits of charged particles in slowly varying fields, introducing and considering rather carefully the significance of the adiabatic invariants of the motion. The first-order orbit theory is then applied to a number of problems, including the equilibrium and stability of plasma in a magnetic field, and the propagation of low-frequency oscillations. There is a brief chapter on plasma oscillations, and a final section in which the possibility of intermolecular collisions is admitted and certain transport processes considered.

The subject is necessarily mathematical in character; but formalism is not allowed to get out of hand. There is no mention of experiment, a particularly unfortunate circumstance in a subject as full of surprises as the physics of ionized gases. The preface confesses that Prof. Chandrasekhar has not read the material, and it is not clear that he would have published it in its present form; however, although not the authoritative monograph for which one might have hoped, this work will be welcome to everyone interested in plasmas, and it should be read by anyone studying theoretical aspects of the subject.

W. B. THOMPSON

THERMAL STRESSES

Theory of Thermal Stresses

By Prof. Bruno A. Boley and Prof. Jerome H. Weiner. Pp. xvi+586. (New York: John Wiley and Sons, Inc.; London: John Wiley and Sons, Ltd., 1960.) 15.50 dollars; 124*s*.

THE authors give a comprehensive survey of methods of calculating stresses and deformations in a solid body due to temperature variations. Elastic, visco-elastic, and plastic materials are considered under static, quasi-static, and dynamic conditions, and sections are included dealing with thermodynamic fundamentals and heat conduction.

The book is divided into four parts, of which the first is concerned with basic thermodynamics, and derives the stress-strain and heat-flow equations. For most practical problems, the terms in the heat-flow equations, representing convertibility of mechanical and thermal energy, may be neglected, so that the calculations of temperature distribution, and of stress and displacement distribution, may be made separately. Most of the problems treated in later sections of the book are of this type. The remainder of the section considers various ways of formulating the thermoelastic problem in 2 and 3 dimensions.

The second part is devoted to the solution of the Fourier heat conduction equation for various boundary conditions. Methods described include the superposition and imaging of sources and sinks and the use of Green's functions, characteristic function solutions, the use of Laplace transforms, conformal mapping, approximate solutions using finite differences, electrical analogues, the variational methods of Kantorovich and Green, and Biot's method, obtaining the equations in Lagrangian form. Static solutions may be extended to cover dynamic cases using Duhamel's theorem.

The third and largest section of the book deals with the determination of stress and displacement for a given temperature distribution for various structural elements. Curved and straight beams, trusses, rings, cylinders, plates, reinforced sheet, and shear-lag problems are dealt with mainly by using the approximations of strength of materials theory, St. Venant's principle being invoked in the treatment of end effects. Exact and approximate theories are compared for the case of the rectangular beam. Semi-inverse methods are used for most of the exact solutions described, energy methods being used to obtain approximate solutions. Other methods described are Goodier's method, the use of centres of dilatation, stress functions, and finite difference and influence coefficient methods. Thermally induced vibrations of plates and beams are briefly considered and there is a chapter on stability.

The fourth part, dealing with inelastic systems, serves as an introduction to a rapidly developing

field. Laplace transforms are used to solve linear visco-elastic problems, and creep buckling is discussed. The final chapter gives examples of plate and cylinder analysis for plastic materials.

The book covers a wide range, from classical thermoelasticity to recent developments in visco-elastic theory, and it is pleasing to report that the cross-referencing is good. Parts 2 and 3 are largely self-contained, a fact which will be welcomed by readers concerned with practical aspects of the subject. The numerous references to published work are listed, with comments, in footnotes. I feel that a list of references at the end of each chapter, and a list of symbols at the beginning of the book, would have been helpful. Despite these minor imperfections, the book meets a real need for a reference work in English on this subject, and should prove to be of great value to research and design engineers working in this field. B. S. Owen

FLAME PHOTOMETRY

Flame Photometry

By Prof. John A. Dean. (McGraw-Hill Series in Advanced Chemistry.) Pp. viii + 354. (New York: McGraw-Hill Book Company, Inc.; London: McGraw-Hill Publishing Company, Ltd., 1960.) 89*s*.

THE application of flame photometry to the determination of microconstituent elements in biological, mineralogical and related materials has been of continuing interest to chemists since the pioneer work of Lundegaardh on flame excitation, and this interest has increased enormously in the past decade.

The present book by Prof. Dean is a comprehensive account of investigations and of instrumental developments in this field. A general, but adequate introduction dealing with atomization, flame characteristics and the nature of emission spectra is followed by a chapter of particular interest which deals with the use of organic solvents, either added to aqueous solutions to enhance emission by their effect on such physical properties as surface tension and viscosity, or in selective extraction methods to increase the concentration of the test element and reduce interference by extraneous ions.

Following a full description of modern flame photometers, burner systems and photo-sensitive detectors, there is a detailed discussion on interferences arising from flame background, cation and anion enhancement and suppression and spectral coincidences.

Individual chapters are devoted to specific periodic groups giving spectral emission lines and band-heads for various elements, comments on possible interferences and specific applications. Scandium, yttrium and the rare-earths are dealt with, and original spectra of these elements are given. Atomic scientists will notice that beryllium is not mentioned, and that the sensitivity of boron is poor as compared with, for example, the fluorimetric method. Strontium and barium receive detailed treatment.

The principles of atomic absorption spectrophotometry are only briefly discussed, and one hopes that, in view of the interest shown recently in the possibilities of this technique, it will not be long before Prof. Dean deals more fully with this subject.

The later chapters are concerned with the determination of non-metals and with agronomic, clinical and botanical applications. An extensive bibliography of 780 references is given which covers a wide range of materials and analytical procedures.

The book will prove a most valuable working volume for the laboratory and has much to offer the student of spectrophotometry. H. L. Bolton

INTERIOR BALLISTICS OF ROCKET MOTORS

Rocket Propellant Handbook

By Boris Kit and Douglas S. Evered. Pp. xiv + 354. (New York and London: The Macmillan Company, New York, 1960.) 12.50 dollars; 87*s*. 6*d*.

Liquid Propellant Rockets

By David Altman, James M. Carter, S. S. Penner and Martin Summerfield. (Princeton Aeronautical Paperbacks, No. 1.) Pp. v + 189. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1960.) 2.95 dollars; 24*s*. net.

Solid Propellant Rockets

By Clayton Huggett, C. E. Bartley and Mark M. Mills. (Princeton Aeronautical Paperbacks, No. 2.) Pp. v + 167. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1960.) 2.45 dollars; 20*s*. net.

Solid Propellant Rocket Research

A Selection of Technical Papers based mainly on a Symposium of the American Rocket Society, held at Princeton University, Princeton, January 28, 29, 1960. Edited by Martin Summerfield. (Progress in Astronautics and Rocketry, Vol. 1.) Pp. xix — 692. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1960.) 6.50 dollars.

ROCKET motors are mechanically simple devices; that they are nevertheless difficult to design and expensive to develop is due to the fact that present-day quantitative knowledge of the relevant chemical and physical processes is still hopelessly inadequate. The upper limit to the performance of a rocket is relatively easy to predict: only the laws of thermodynamics are required, coupled with the availability of the thermodynamic properties of the propellants, the assumption of equilibrium, and the ability to obtain numerical solutions to a dozen or so simultaneous non-linear algebraic equations. It is the rate processes which present the difficulty: how large the motor must be for a given approach to the maximum performance depends, for example, on rates of chemical reaction, on the fluid mechanics of droplet break-up, and on the interactions between finely divided solids; none of these processes can be accurately computed at present.

In these circumstances, design must proceed mainly by trial and error. The role of theory is reduced to that of investigating models which are no more than caricatures of reality. Such investigations are successful if they correctly predict the trends of the performance variations resulting in changes to the design; for they can then guide the development engineer in the most hopeful directions and assist him to distinguish between major and

minor influences. Such models are needed both for 'normal' and 'abnormal' operation, that is, for the desired smooth and steady burning, and for the unsteady phenomena, known as 'chugging', 'chuffing' or 'screaming', which all too often intervene at the last moment to destroy a promising design. It appears likely that steady burning in liquid-propellant motors is best represented by models in which the flight and vaporization of droplets play the major parts with the atomization process, one which must be studied experimentally. Steadily burning solid-propellant rockets conform well to the supposition that the burning-rate per unit area of propellant surface area depends mainly on pressure, and secondarily on initial temperature and transverse gas velocity; these dependences have, however, to be determined experimentally for each propellant. The most disastrous type of unsteady burning, 'screaming', is known to involve, for both classes of rockets, large-amplitude acoustic vibrations within the combustion chamber; but the nature of the interactions with the combustion process by which the vibrations are driven remains an almost complete mystery.

To turn now to the four books under review, the first, by Kit and Evered, is a contribution to the simplest aspect of the problem: the thermodynamic prediction of maximum performance. The authors have collected all the relevant thermodynamic data they could find, and presented it in the form of tables with connecting discussion. The enterprise is a useful one, and the result will be accepted gratefully by propellant-system designers; the gratitude of the latter will, however, not be unmixed with dismay, and occasional fury, when they find that vital information has carelessly been omitted. To take the first entry of Table 1–1 as an example, the authors state that the heat released in the hydrogen–oxygen reaction is 57·80 kcal./gm. mole; temperature and phases are not indicated. Two pages later we are told that such figures 'usually' relate to 1 atmos. and 25° C., and that the phase of the H_2O "must always be stated"; but they still fail to give that information. There are numerous such small but paralysing omissions in the book.

The two paper-back books, *Liquid Propellant Rockets* and *Solid Propellant Rockets*, are reprints from the Princeton series of volumes on high-speed aerodynamics and jet propulsion; they have been made available for the benefit of students. I am not enthusiastic about them for this purpose, for they lack the formal organization, carefulness of definition and freedom from distracting speculative material which students justifiably expect; they are also, of course, considerably out of date. The article on liquid-propellant motors by Summerfield may serve as useful background reading, but that on thermodynamics by Altman and Carter can only confuse, while the solid-propellant sections are chiefly of historical interest.

Solid Propellant Rocket Research falls into an entirely different category. It contains the papers presented at the symposium held at Princeton in January 1960, under the auspices of the American Rocket Society, together with a few additions. Sections included are: mechanical properties of grains (that is, of solid-propellant charges), steady-state burning mechanisms, combustion of metals, theories of unstable combustion, experiments on unstable combustion, and solid-propellant ignition. The book gives an impressive view of the magnitude and vigour of the present effort being made by the United States in this field; it also adds emphasis to the remarks about present ignorance made at the beginning of this review. To cite two examples, though both Nachbar and Summerfield *et al.* present theoretical models for the burning process of composite propellants, none of the authors would claim that the models can be made to fit experimental findings for more than a very restricted range; the relation of the theories of oscillatory burning to the experimental facts is still more tenuous. Nevertheless, if money, man-power and professional expertise can find solutions to these problems, few can doubt that it is the American workers who are most likely to succeed. D. B. SPALDING

THE NEW LOOK IN MATHEMATICS

Mathématiques Générales

Algèbre—Analyse. Par Prof. Charles Pisot et Prof. Marc Zamansky. (Collection Universitaire de Mathématiques, 4.) Pp. xxiv+648. (Paris: Dunod, 1959.) 4,500 francs.

TO those brought up on a *Cours d'Analyse* of the classical French tradition, the new look is austere. Pisot and Zamansky have planned their book for students just beginning a university course in mathematics, of honours standard, working on a basis acquired at school, which, the authors assert frankly, is insufficient in some aspects and useless in others, though they are optimists enough to believe that, in France at least, this state of affairs will be remedied in a few years.

There are four main sections. The first introduces logical notions and the elements of set theory, with illustrations to show that many of these ideas are known at school, if not clearly identified there. The second section is on algebra, mainly linear algebra: the fundamental ideas of a vector space and the linear mapping of one vector space on another serve to give, in compact form, the basic theory of matrices, determinants and related concepts. The section on analysis is based on two main principles: first, the Cauchy sequence $\{x_n\}$ in which $x_p - x_q$ tends to zero as p and q tend to infinity; secondly, the doctrine, somewhat subtle at this stage, of uniform convergence. Early introduction of this latter concept allows much use of piece-wise constant functions. Thus, for example, an integral can be defined more or less intuitively for these functions, and then extended to limits of sequences of such functions; this establishes the existence of integrals for all the functions ordinarily encountered, though it does not quite give the Riemann integral. But most analysts would now maintain that the persistence of the Riemann integral is due to "the stubborn conservatism of academic tradition", and the approach to integration in this volume would carry over quite easily to Lebesgue integration. Most of the technique of analysis is reserved for the final section, which includes some work on differential equations.

How would this book fit into a British course? Some of the ideas are already incorporated in our courses, though perhaps not as first-year work, and

more will undoubtedly follow. But how much? A comparison of this book with the new volume by Dieudonné, *Foundations of Modern Analysis*, shows that the former is itself still a compromise between the classical and the contemporary in analysis. Dieudonné, we may suppose, represents the pure gospel according to Bourbaki, when he insists on the modern emphasis on conceptual notions, as opposed to the computational aspect expounded, for example, in Whittaker and Watson. His is the remark above about the Riemann integral. If the older analyst should doubt whether the concept-conscious undergraduate would succeed with, say, some of the stiffer examples in Whittaker and Watson, it would certainly not be quibbling to suggest that there is no reason why he should: indeed, the epsilon-conscious undergraduate of the 1920's might have been no more successful with some of Wolstenholme's teasers on conics. Mathematics changes in mode as it grows in content, and the undergraduate must be taught in the style and idiom of living mathematics. Yet this may not be a complete answer, save as regards the training of pure mathematicians. It is true that certain concepts of modern abstract mathematics have found a place in branches of mathematical physics, but too much abstraction might hamper the student whose chief interest in mathematics lies in its physical applications. Are we then to impose an early separation between the pure and the applied mathematician? Before accepting this harsh doctrine, we may remember that Maxwell, Rayleigh, J. J. Thomson were all products of the old Tripos, and hope that some British mathematician will set himself the task of writing a text for our universities which will weave together the modern abstract concepts with the older computational technique, which will absorb Bourbaki without exorcising Whittaker and Watson, which will save us from the sterility of ideas without technique and from the superficiality of technique without ideas.

T. A. A. Broadbent

PICTORIAL GUIDE TO THE LANGUAGE OF SCIENCE

Mathematics in the Making

By Lancelot Hogben. Pp. 320. (London: Macdonald and Co. (Publishers), Ltd., 1960.) 50s. net.

"SCIENTISTS need to be taught mathematics", Sir Cyril Hinshelwood has said, "as a language they can actually speak"; one implication of this is that those non-scientists who wish or need to know what modern science is doing should have some knowledge of the mathematical language, though a phrase-book may serve them instead of a complete grammar and dictionary. Hogben has given us a vivid and stimulating phrase-book, built up in roughly chronological order, with a wealth of coloured plates, diagrams and pictures. The representations of three-dimensional surfaces, for example, are so admirable that some irrelevancies—Samurai, the mosque at Cordova—can be forgiven. The team-work which has gone into the making of the book deserves all the praise which Hogben bestows on it.

Neugebauer and Needham have thrown a completely new light on early mathematics in Egypt, Mesopotamia, China, India, and Hogben's account is clear and illuminating. He is rather less at home with the Greeks, since he under-estimates the importance of the Greek contribution to the concept of mathematical proof, and over-estimates the role of measurement in mathematics. Hogben says that we must learn to communicate in language which the electronic brain understands; the mathematician would say that the electronic brain has been constructed to obey the commands given to it in our language.

The influence of the Moslem civilization bridges the gap in the Western World from the Hellenic legacy to the seventeenth century. Here Descartes showed us how to describe geometrical properties in algebraic language, Fermat groped towards the Newton–Leibniz calculus, Pascal and Bernoulli initiated the doctrine of probability. On probability, the author is at his best; his enthusiasm is infectious, his excellent diagrams and pictures are genuinely constructive, and his somewhat old-fashioned obsession with visual aids is pardonable. By way of contrast, there is much clumsy symbolism and heavy-handed manipulation in dealing with algebraic geometry and calculus. More modern mathematics is dismissed briefly: hasty references to topology, non-Euclidean geometry, an ugly version of vector algebra lacking any motivation for the non-commutative product, Boolean algebra and recent views on logic and the nature of mathematics. The author is willing to deal sketchily with these topics because, to use a favourite phrase of his, they have as yet had little or no 'pay-off'. But it may be fair to suggest that there is a further reason; Hogben has no interest in or liking for mathematics as a creative art. This may well diminish the value of his book to the many amateur students of mathematics who, outside their surgeries, court-rooms, offices, enjoy the delights of mathematical investigation without worrying very much about the material 'pay-off'.

Success for the book is certain, and, on the whole, well deserved. There is a warmth and vitality which over-ride some minor irritations. Ideological epigrams about Roman gangsters, remittance men in Kenya and the third person of the Trinity can be ignored.

T. A. A. Broadbent

ELECTRON MICROSCOPY

Vierter Internationaler Kongress für Elektronenmikroskopie

Berlin, 10–17 September, 1958. Verhandlungen Band I: Physikalisch-Technischer Teil. Herausgegeben von G. Möllenstedt, H. Niehrs und E. Ruska. Pp. xix+851. 228 D.M. Verhandlungen Band II: Biologisch-Medizinischer Teil. Herausgegeben von W. Bargmann, D. Peters und C. Wolpers. Pp. xv+649. 196 D.M. (Berlin: Springer-Verlag, 1960.)

BETWEEN them, these two volumes contain more than 1,500 pages and nearly 1,700 illustrations, mostly electron micrographs very well reproduced. Of the 400 separate contributions, just one-half are in English, one-tenth in French and the remainder in German; the authors come from 26 different countries (as the foreword tells us), and the subjects dealt with run into almost every conceivable branch of science and technology. Volume I, devoted

to the physical basis and technological applications of electron microscopy, is almost half as long again as Volume 2, which comprises the biological and medical applications. This uneven division confounds the view that the development of the instrument is more or less complete and that the subject is now mainly concerned with its uses, particularly in biological investigations. In fact, more than half the first volume is taken up with papers on the principles, design and operation of the electron microscope, and with basic preparative methods, such as shadow-casting and object supports. The interaction of the electron beam with the specimen is now also receiving considerable attention, especially the removal of material from embedded sections. Field emission microscopy, to which a special symposium was devoted, is represented by sixteen papers.

Compared with the previous conferences, the most striking change is the increase in metallurgical applications. More than sixty papers are concerned with crystal growth, the origin and movement of dislocations, and transition and precipitation processes in metals. This increased activity is largely due to the methods developed in the past few years of preparing, from bulk metal, films thin enough for electron microscopy, an advance comparable with the revolution in biological work when the technique of cutting very thin sections of tissue was devised. The metallurgist is in a better position, however, in that he can carry out meaningful experiments on his specimen while it is in the electron beam. Several papers describe attachments for heating, cooling and straining a metal film, and a number of cinematographic records have been made of the resulting changes. We may now expect to see the same rapid extension of electron microscopy into metallurgical laboratories, as occurred earlier in biology.

A fair number of ultra-microtomes is now available for cutting sections down to about 100 Å. thickness; one or two are described in Volume 2 and more were on show at the conference. Biologists of all kinds are now busily engaged in sorting out the unexpectedly rich micro-anatomical detail revealed by this new technique in all tissues and micro-organisms. Almost the whole of Volume 2 is taken up with papers describing observations on thin sections, under the headings of cell morphology, anatomy, pathology, botany and micro-biology. The latter section also includes much work on the structure of isolated bacteria and especially of viruses. In general, biologists are now engaged with the electron microscope in the same sort of rapid extension of structural knowledge as was made possible by improvements in the optical microscope in the last half of the nineteenth century. To complete the picture, active efforts are being made to discover suitable means of staining particular cell components with compounds of high density, so as to show them up in the electron image.

The Berlin conference was by far the biggest of the four international meetings on electron microscopy so far held. Since for much of the time there were four parallel sessions, it is most valuable to have a permanent record of the contributions. The editorial committee of the German Electron Microscopical Society has gone to great trouble to make the record complete, and the publishers have given us a work which is in the best traditions of German book production. However, one cannot but ask if it is not too much (in bulk and in cost), and too late. This standard of presentation is right and proper for a subject which has reached a certain state of finality: the *Handbuch der Physik* is all that one could require. But electron microscopy is still in rapid flux: many of the findings reported here are provisional and most of the authors are likely to have published one or more further papers in specialist journals during the two years which it took to produce these proceedings. As a survey of the state of electron microscopy in 1958 they are a most admirable record. For the working scientist it would be more useful to have a much quicker, but technically speaking a poorer, printing of the manifold contributions, so that he could refer to them while they were still relevant to work in progress, and also, if this be not too vain a hope, so that the price could be low enough to have a copy on his own shelves as well as in the library. Active exploration of alternative ways of publishing conference proceedings are urgently necessary; one such experiment is now in progress in connexion with the European conference on electron microscopy held in Delft in 1960. V. E. Cosslett

X-RAY DIFFRACTION PHOTOGRAPHS

The Interpretation of X-ray Diffraction Photographs

By Dr. N. F. M. Henry, Prof. H. Lipson and Dr. W. A. Wooster. Second edition. Pp. x+282. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1960.) 63*s*. net.

THE battered condition of the reviewer's copy of the first edition (1951) of this book testifies to its value to generations of impecunious research students. In the second edition, the authors have maintained the high standards set by the first, and in their preface they explain that parts of the book are corrected, but substantially unchanged, and new sections have been added to deal with techniques which have come into general use in recent years, for example, the counter diffractometer.

The main emphasis is the same as that of the first edition, namely, on explaining crystal lattices, the geometry of X-ray diffraction and how to index good X-ray photographs of various kinds. These topics are treated in considerable detail and explained clearly by means of fully worked examples. An outstanding feature of the treatment is that the examples chosen illustrate the difficult cases encountered in practice, and the explanations are explicit. Triclinic and rhombohedral examples are given in detail and not avoided by the not uncommon practice of assuring the unwary reader that "extensions to systems of lower (or higher) symmetry are obvious". Only very elementary knowledge of mathematics is assumed; normally, explanations are given in geometrical terms aided by extremely good diagrams. The problems, with answers in an appendix, are a most useful feature for the beginner. Appendixes contain tables of formulæ, of multiplicity factors and of crystal classes and their physical properties.

For the chapters devoted to detailed explanation, the book can scarcely be bettered; unfortunately, apart from a masterly chapter on the properties of X-rays, those in which topics are outlined are

disappointing. For example, a reference (1930) is given for the application of a correction to apparent intensities measured on oscillation photographs, but none for the other kinds of photographs now in more common use. Similarly, there is some vagueness about problems concerning crystals which are unsuitable for accurate morphological measurement. Thus, although the unit cell dimensions of monoclinic crystals have actually been measured accurately by purely X-ray methods, the beginner might not realize this from "but, no doubt, by suitably choosing reflections, it should be possible to devise methods similar to those described in 13, 4·2". It seems a pity that, after so much trouble has been taken to make the reader familiar with the reciprocal lattice, the tables of correction factors are given in terms of θ instead of $\sin\theta$.

In a book of this kind it is extremely difficult to avoid numerical typographical errors, and even three authors have not been sufficient to prevent some from appearing.

These are minor criticisms of a book which is, on the whole, extremely good. The printing and paper are good and the diagrams excellent. Both beginners and experienced crystallographers will find much of value in this book, which is not unreasonably priced.

M. R. Truter

MODERN MINERAL TECHNOLOGY

International Mineral Processing Congress, 1960

Proceedings of a Congress arranged by the Institution of Mining and Metallurgy, held on 6th to 9th April, 1960, at Church House, Westminster, London S.W.1. Pp. xiii+1118. (London: Institution of Mining and Metallurgy, 1960.) 100*s*.; 14.50 dollars.

THIS volume contains the inaugural address, the fifty-two papers and their discussion at the 1960 International Mineral Processing Congress, the fifth of these meetings to be held since the War. The change of title from 'ore dressing', 'mineral dressing' and 'mineral engineering' still leaves this ebullient engineering science inadequately described. A stroke of genius is needed which will bring its activities in metallurgy, chemical engineering, physical chemistry, electromagnetics, nuclear physics and the rest to a titular focus. As with the previous congresses, held in Britain, France, Germany and Sweden, papers from leading laboratories and industrial operators in many mining countries are roughly grouped—in this case in nine divisions. Detailed review of such a mixed bag is impossible. The work recorded shows that the challenge of industry continues to be met at all levels, from improvement of established processes to creation and development of the new ones required by the insatiable demand of modern civilization for metals, earths and high-purity mineral concentrates.

The first group of five papers deals with comminution, the step in ore treatment in which valuable minerals are exposed for surface attack or detached from the accompanying gangue. New methods of grinding, some with a discipline of statistical mathematics, are described. Papers 6–10 deal with particle dynamics in aqueous media, both under conditions of free fall and of centrifugal acceleration. X-ray scanning of opaque slurries is described. By the aid of these techniques large tonnages of 'pulp'—an aqueous suspension of small particles, mostly less than 20 μ in diameter—are controlled as to size, shape and/or mass into equal-responding fractions. This, coupled with the comminuting processes, is an essential preliminary to concentration (separation of the various mineral species in the ore).

In papers 11–18, fundamental physical chemistry is related to flotation research. Improved methods of micro-auto-radiography are described in connexion with adsorption of tagged reagents to mineral surfaces. Relative rates of reaction in response to surface agents, the mechanisms of complexing, physical stability of sorbed layers and reactions in the zeta zone which surrounds a particle in aqueous suspension are investigated, using ultrasonics, photomicrography and thermochemistry. The transporting role of air is considered, using contact-angle measurement or over-gassed water. The depressive effect of typical accompanying minerals in sphalerite ore undergoing flotation is shown. In the next group of papers (19–23) advances in flotation practice are described and process economics receive some attention.

Interest in the older processes of concentration by gravitational force continues to stimulate research (papers 24–30). Jigging of transparent objects in organic liquids and the study of stratifying action show the value of statistical appraisal in complex problems of dynamics. Dense-media separation finds a novel control valve in the shape of a magnetic field which constrains the ferro-magnetic media at the under-flow end of the separating vessel. Tetrabromo-ethane (specific gravity 2·963) is proposed as a dense separating liquid in place of magnetite or ferro-silicon pulped with water, the usual fluid mixture. Cyclone physics continues on its scientifically turbulent course. In commercial practice it has established its value everywhere, but agreement as to how it works is not yet complete.

Papers 31–38 describe advances in the magnetic, electronic and high-tension electrical treatment of ores. The effect of moisture and surface conditioning on the behaviour of small particles in an electrostatic field promises to extend the use of electrostatic separation by improving control. A novelty is the use of a refracted beam of light to trigger a mechanism by means of which diamonds can be automatically removed from passing gravel. Papers 40–44 are concerned with the chemical processing of galena, scheelite, wolframite, some silicate minerals and uranium ores, and the use of autoclaves to aid solvation. These are followed by the last eight papers (39 and 45–52), which deal with process study, control and testing, fluidized-bed roasting, automatic control, statistical analysis and the observation of concentrating techniques performed mechanically on the stage of a microscope.

Despite the fact that many of these highly technical scripts were written in Russian, Japanese, Italian, German and French, the translation is admirable. The book is excellently produced and well indexed. It bears no signs of the problem which bedevils all important meetings today—so much to do, so little time. The subject-matter covered ranges over wide fields of research and production activity, and leaves me more conscious of what has been left out of his conspectus than of what he has crowded in. The book is essential for workers in the integrated field of mineral technology.

E. J. Pryor

SHORT REVIEWS

Sir Isaac Newton

By Dr. H. D. Anthony. (Life of Science Library, Vol. 39.) Pp. 224+10 plates. (London: Abelard-Schuman, 1960.) 21*s.* net.

TO write a readable account of Newton's life and achievements is a task of very great difficulty, as all who have attempted it will agree. Although Newton's extension in time was considerable (85 years), his extension in space was restricted to the neighbourhood of Woolsthorpe, Cambridge and London. His achievements in astronomy and mechanics are not easy to explain, owing partly to the confusion surrounding his definition of 'mass', a definition which was wrongly translated by the exponents of his mathematical principles of natural philosophy from his day until the present. An exception was Henry Pemberton, one of the young men who received generous help from Newton, and who had the privilege of reading over, with him, the manuscript of his *View of Sir Isaac Newton's Philosophy* (1728). Newton defined mass as a 'measure'—not something which a body had, which 'could' be measured.

Dr. Anthony has succeeded in overcoming these difficulties by giving a more balanced account of Newton, including considerably more detail about his early life and contemporary background, his emergence into public life, his activities at the Mint and his theological writings, than has been usual in former biographies. The explanation of Newtonian dynamics is lightly but clearly outlined, with the exception of a paragraph on the tides, where we are unfortunately told that neap tides occur at full moon. Two minor errors are: "Sir" Robert Boyle (p. 102), and "the American airmen who made the first Trans-Atlantic flight" (p. 41). The author has forgotten two of Newton's countrymen who also voyaged "through strange seas . . . alone".

This is a well-produced book with excellent illustrations. An appendix containing interesting notes on the illustrations, a useful short bibliography and an explanatory list of words used with special meanings in British universities (for example, subsizar), all contribute to making this volume one that can be strongly recommended. G. BURNISTON BROWN

Science in Writing

A Selection of Passages from the Writings of Scientific Authors, with Notes and a Section on the Writing of Scientific Prose. By T. R. Henn. Pp. 248. (London: George G. Harrap and Co., Ltd., 1960.) 20*s.* net.

IT is a pity that so much scientific prose fails to be beautiful. Yet scientists in the past and of to-day have succeeded in writing with mastery. Mr. Henn has chosen examples from the works of several scientists ranging from Pliny to living authors.

These passages are not presented as models to be imitated, but they help to illustrate very cogent suggestions for good writing which Mr. Henn gives in the last part of his book. He feels that these authors have excelled because they have controlled their material so well. This control is derived from sheer knowledge of the facts and a persistent quest for what is relevant until "the whole assumes an ordered and organic pattern".

It is intriguing to see how devices of style are used (consciously or otherwise) and how the personality gleams through the prose. Newton's symmetry of thought, his dignified and authoritative tone are evident. Rayleigh's style, as complete in itself as a Mozart string quartet, would suffer loss were attempts made to amplify or compress it in any way. Darwin develops his argument simply and modestly yet evoking excitement. Allbutt's "sweeping brush-strokes" are a contrast to Duke-Elders's gradual unfolding of ideas. Punctuation is used by Whitehead, Max Born, Hinshelwood and Ricardo to give a limpid flow and abounding clarity. As in 'humane' prose, there can be scope for imagery and rhythm. Contrasted and associated rhythmic sequences can give a breathing quality to prose, so making it more pleasurable to digest. Imagery may provide analogies, may convey shades of meaning; sometimes frankly poetic as in Jacquetta Hawkes's writing.

The book should interest any scientist who wishes to write well. RUXTON VILLET

The Wildbooters

By Fritz Kern. Pp. xi+204. (Edinburgh and London: Oliver and Boyd, Ltd., 1960.) 21*s.* net.

THIS is an English translation, edited by K. J. Narr, of the late Prof. F. Kern's *Der Beginn der Weltgeschichte* (1953). Its thesis is the same as that put forward by Prof. W. J. Sollas in *Ancient Hunters* (1911), that archæology and ethnology can be combined to present "a picture of the early history of mankind" (p. 54). Wildbooters, Kern's word for hunters and collectors, replaces ancient hunters, protolithoid Lower Palæolithic, and instead of Australians (Palæolithic), Eskimo (Magdalenian) and Bushmen (Mesolithic), Ituri Pygmies, Chenchus and Yamanas are chosen to reveal the "essential traits" of man's "basic culture"; but the objections to this thesis remain the same. Archæology is a science, ethnology is not; the cultural stratigraphy of the ethnologist is one thing, that of the archæologist is another; and "reconstructive imagination" is no substitute for factual history. The first six chapters attempt to summarize and synthesize the prehistoric racial and archæological background, the seventh deals with the oldest cultural (ethnological) stratum, the rest describe the economy, religion and social organization of this stratum as deduced from ethnological accounts of their modern survivors.

There are no bibliography, maps or index. *The Wildbooters* provides a stimulating hypothesis of the life of early man, but archæologists and ethnologists will demand more detail, social anthropologists will wonder why so many of his sociological data are drawn from such little-known and inadequately studied tribes, while the general reader will be defeated by the morass of conflicting racial and archæological theories in the first few chapters. G. I. JONES

Archæological Investigations in British Guiana

By Clifford Evans and Betty J. Meggers. (Smithsonian Institution: Bureau of American Ethnology, Bulletin No. 177.) Pp. xxi+418+68 plates. (Washington, D.C.: Government Printing Office, 1960.) n.p.

THE authors, who are well known for their work at the mouth of the Amazon and other parts of lowland South America, spent the winter of 1952–53 in British Guiana. Their report can be assumed to have answered most of the questions of any importance which are likely to arise in the archæology. There is, however, one important problem, probably insoluble, to which they direct attention for the first time, namely, the possible existence of an early hunter horizon of the age of the first occupation of South America. The evidence consists of seven large stemmed stone points, four of which they illustrate, to which I may add three of rather different form in the University Museum of Archæology and Ethnology, Cambridge. All are casual finds, they are unlike anything known of later date, and the possibility of finding a site which puts them in their context is remote in the environment.

For the rest, the work covers the North-West District and two inland areas. The first produced a pre-ceramic shell-mound stage, with polished-stone tools and extremely crude percussion-flaked ones, with pottery and agriculture coming into its latest stages, perhaps from Venezuela. It is ascribed to the early centuries A.D. There follow three distinct ceramic phases, the first from Venezuela *c.* A.D. 500, the second from Trinidad *c.* 1100, and the third probably from the East *c.* 12–1300. All lasted until the arrival of the Europeans. The inland areas, the Rupununi Savanna and the Upper Essequibo, were chosen as likely ones for finding traces of people immigrating from the south. Traces were indeed found in the shape of distinctive pottery, but all belonged to people known to have come after 1670, some of them, the Wai-Wai, very recently indeed.

The sum of it all is that British Guiana was never a great centre of aboriginal development and had no great attraction for them. Various peoples entered it from time to time, most of them at a late period, and probably under pressure.

G. H. S. BUSHNELL

Natural Selection in Human Populations

Edited by D. F. Roberts and G. A. Harrison. (Symposia of the Society for the Study of Human Biology, Vol. 2.) Pp. viii+76. (London and New York: Pergamon Press, 1960.) 20*s.* net.

IN the first paper, "Natural Selection in Man: Some Basic Problems", Prof. L. S. Penrose discusses the particular genes recognizable in human populations in terms of their frequencies, precise effects, origins, degrees of stability, and quantitatively observable trends. The popular view that present-day cultural practices have abolished the effects of natural selection upon our species is rejected. Rather, the process has been transferred at certain points from one genotype to another, as may be observed in the role that medical control of infectious disease has exerted in reducing the advantage of those genes whose frequency in the gene pool was once maintained for fighting disease. Dr. Penrose regards the primary force of selection today to be directed towards the embryonic level, where most anomalies occur. Such selectivity does not harm the gene pool since its victims do not live to reproduce.

Dr. A. R. G. Owen's paper, "Mathematical Models for Selection", approaches selection in terms of its effects solely upon the genotypes themselves. His mathematical model is a representation of the polymorphism of multiple alleles which he suggests as a means of approach to the complex factors of heterozygosity.

"The Relative Fitness of Human Mutant Genotypes" by Dr. C. A. Clarke and "Natural Selection and Some Polymorphic Characters in Man" by Dr. P. M. Sheppard are clinical approaches to those gene complexes we identify as the units of human polymorphism. The fourth contribution to the Symposium, by Prof. T. Dobzhansky, "On Selection of Gene Systems in Natural Populations", emphasizes the frequently overlooked fact that natural selection works on organized gene systems rather than on single discrete genes which are the concern of some human geneticists embogged at the biochemical level.

The final paper, which is by Dr. Ashton, "The Rate of Change in Primate Evolution", is essentially a review of the primate fossil record and of studies of the St. Kitts green monkey population. Dr. Ashton regards the rate of morphological change for the primates as completely indeterminable.

This collection of researches should be useful to the physical anthropologist concerned with problems of human genetics and the intellectual history of this phase of the discipline. As a broad study of natural selection in human groups the book is only partially successful. Little attention is given to the cultural factors affecting the frequencies and distribution of human polytypes. An understanding of that relationship of social tradition to genetic complexes is the very crux of anthropological theory.

KENNETH A. R. KENNEDY

Mechanisms in Radiobiology

Edited by Maurice Errera and Arne Forssberg. Vol. 2: Multicellular Organisms. Pp. xiii+395. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1960.) 13 dollars.

THIS is not a text-book. The five chapters, all by different authors, show little sign of editorial integration and vary greatly in quality. "Gametes and Developing Embryo", by Roberts Rugh, is a useful literature source, but by no means easy reading. Rugh's contention that cells are more radiosensitive during differentiation than during division may help to loosen some of the present fixity of radiobiological thought. "The Adult Organism", by Clemedson and Nelson, is the least satisfactory chapter in the book. It is not only uncritical but seriously incomplete. For example, there exist six classical papers concerning radiation effects on the thymus, but only one of these is mentioned and that incorrectly. Structural changes in the retina, on which there is an important literature, are dismissed in five lines. Testis and ovary could have been omitted in view of their more complete coverage in Rugh's chapter.

"Immunology", by Hašek and Lengerová, is too short (sixteen pages, excluding chimeras) to do justice to this important topic. "Protective and Sensitizing Action", by Eldjarn and Phil, is a good and critical survey, despite its somewhat pro-SH bias.

The last chapter, "Recovery and Therapy", by van Bekkum, seems quite outstanding. Not only is it aptly critical and fully informed, but also the author has been able to digest his material and present it in a gracious literary form, and much wisdom withal: a model of science writing. O. A. TROWELL

Scolt Head Island

Edited by Prof. J. A. Steers. Revised edition. Pp. xi+269+29 plates. (Cambridge: W. Heffer and Sons, Ltd., 1960.) 50*s*. net.

SCOLT Head Island is a strip of marshland, shingle ridges and dunes approximately four miles long, lying off the north Norfolk coast between Burnham Overy Staithe and Brancaster. Of the seventy-odd statutory Nature reserves which now exist throughout Great Britain, it can justly hold pride of place as one of the most intensively studied by botanists, zoologists and physiographers. The present volume provides ample testimony to the work of a great number of individuals during the past thirty-five years or so. As is to be expected, the physiography and evolution of the Island receive extensive treatment, evidence being provided of the structure of the various marshes, their rates of accretion and the influence of extraneous forces on them. The Island is evidently in a state of dynamic equilibrium, the beaches and dunes being built up at one time and eroded at another. Such circumstances demand constant adjustment and great adaptability by plant and animal colonists, and so provide wonderful opportunities for the ecologist. That these opportunities have been fully realized is evident from the accounts of pollen analysis in the peat and the detailed studies of flowering plant and bryophyte ecology. Of the animals, birds are treated in some detail with particular reference to terns, wildfowl and waders. There is a useful section on marine invertebrates and an interesting account of terrestrial molluscs in relation to the fluctuating variety of habitats that the Island has to offer. The insects of the Island appear to have been studied less than the other groups already mentioned, and the account of their ecology is rather fragmentary. Clearly, there are opportunities here for the investigation of micro-evolutionary changes for which they might provide admirable material.

The reappearance of this splendid symposium in revised and expanded form will be welcomed by anyone with a love of ecology and natural history. It provides an example of the eco'ogical survey at its very best. W. H. DOWDESWELL

Schizophyzeen

Von Prof. Dr. Lothar Geitler. 2, umbearbeitete Auflage. (Handbuch der Pflanzenanatomie, Band VI, Teil 1. Zweite, völlig neubearbeitete Auflage herausgegeben von Prof. Dr. W. Zimmerman und Prof. Dr. P. Ozenda.) Pp. vii+131. (Berlin-Nikolassee: Gebrüder Borntraeger, 1960.) 57.50 D.M.

IT would be a mistake to assume that this volume, as might be suggested by the title of the series, deals only with the gross structure of the Schizophyceae—or, as they are better known in Great Britain, the Cyanophyta, Myxophyceae or blue-green algae. The author has interpreted anatomy in a broad sense, and almost every page has reference to other features of wider interest.

The morphological range in the group is adequately summarized, but in addition there is a particularly good account of modern work on the structure of the protoplast, a subject of considerable importance on account of the low level of cellular organization as revealed by the absence of differentiation into nucleus and cytoplasm. That botanical enigma, the heterocyst, also receives adequate treatment, but it would seem that there is still no satisfactory explanation as to the function, if any, of this peculiar type of cell.

The text is illustrated by many fine figures, while the printing and binding are all that could be wished for.

The Birds of the British Isles

By Dr. David Armitage Bannerman. Illustrated by George E. Lodge. Vol. 9: Scolopacidae (Part). Pp. xii+398+26 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1961.) 63*s*. net.

THIS ninth volume (with three still to come) is devoted entirely to the Scolopacidae and does not, indeed, completely cover that large family. Here we have the curlews, godwits, and an array of sandpipers; the phalaropes, separated by some authorities, are also included. So many of these species are not natives of the British Isles that Dr. Bannerman has had to be even more assiduous than usual in gathering extraneous material for full accounts of their life-histories. In doing this he has drawn on a wide knowledge of the literature and information supplied by correspondents, while other authors have contributed certain sections by invitation. In this way the birds are followed on one hand to breeding grounds in the high Arctic or in North America or Asia, and on the other to winter quarters by tropical coasts, rivers and lakes—a valuable compendium of evidence. Some of these 'waders' (or 'shore-birds' as the Americans have it) were among the best subjects of the late George Lodge's artistry. LANDSBOROUGH THOMSON

The Monarch Butterfly

By Dr. F. A. Urquhart. Pp. xxiv+361+12 plates. (Toronto: University of Toronto Press: London: Oxford University Press, 1960.) 52*s*. net.

IN a well-printed and well-produced book of 350 pages and twelve coloured plates, Dr. F. A. Urquhart, of the Royal Ontario Museum, has produced a very full account of the monarch butterfly, *Danaus plexippus* Linn., particularly from the point of view of its life-cycle, its habits—including its remarkable annual migrations—and its relation to other species in a 'mimicry' complex. The first part of the book, 96 pages, is a general survey; the second gives in more detail the investigations carried out by Urquhart and his collaborators in the field during many years.

Nearly all the book is of interest to the field naturalist, but its most outstanding contribution is undoubtedly the results of the author's work on marking of the butterflies on their autumn and spring migrations, and recoveries at great distances. It has been generally accepted for many years that the monarch in North America must migrate over long distances to the south in the autumn and back to the north in the spring, but absolute proof was lacking.

Marking experiments with insects have been tried in many countries in the past thirty years, but the number of recoveries at any long distance has been negligible. Urquhart has been much more successful. Out of many thousands of butterflies marked, chiefly in the autumn at the beginning of their southward movement, but some also in the spring, his list of recoveries includes 98 in the autumn and 13 in the spring at more than 13 miles from the place of marking. Of these the maximum distance for a spring marking was 600 miles; while for the autumn movement there were 25 recoveries at more than 350 miles, of which 8 were more than 1,000 miles. The most distant recovery was one marked in Ontario on August 18, 1957, and recovered on January 25, 1958, in San Luis Potosi, Mexico, a distance of 1,870 miles in a direct line. For these results alone the book should be in every library.

C. B. Williams

Solubilities

Inorganic and Metal-Organic Compounds—a Compilation of Solubility Data from the Periodical Literature. By Dr. Atherton Seidell. Vol. I: A–Ir. Fourth edition by Dr. William F. Linke. Pp. iv + 1487. (Princeton, N. J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1958.) 187*s.* 6*d.*

PROBABLY every scientific library contains at least one of the complete editions of this famous series *Solubilities*, first published by Dr. Atherton Seidell in 1907.

A regular revision of a compilation of data of this nature is absolutely imperative if the work is to provide the scientist with the most recent and up-to-date information. Even in the short period of a decade, numerous original investigations on organic and inorganic solution equilibria are published in the multitudinous modern scientific periodicals and journals, and all these require a critical periodical assessment and tabulation.

The volume under review is the first of the new fourth edition, revised and compiled by Dr. W. F. Linke, and is the result of a detailed, critical study of investigations recorded in the chemical abstracts up to the 1956–57 period. The data of various authors on particular substances have been compared and combined; unreliable observations have been omitted, whereas closely agreeing results are plotted and averaged.

As in the well-known earlier editions, the elements are listed alphabetically according to their chemical symbols, and the anions of compounds also fall into a similar alphabetical sequence. A welcome innovation to the present edition is the inclusion of a complete index of substances and compounds which renders the location of specific data a much more facile procedure. The usual author and reference index is extensive and comprehensive.

This new edition is to be published in three volumes. The first volume covers argon to iridium, and volume 2 will complete the inorganic compilation. Volume 3 is to be devoted to the solubilities of organic compounds in various solvents.

The new series comprises a valuable modernized edition of a reference work which has been of the greatest value to chemists for more than fifty years, and, like a good wine, it 'needs no bush'.

D. T. Lewis

Advances in Clinical Chemistry

Vol. 3. Edited by Harry Sobotka and C. P. Stewart. Pp. xiii + 400. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1960.) 12 dollars.

THE third volume of this useful annual, which has now established itself as an essential piece of equipment on the desk of every hospital biochemist and which can be read with profit by general biochemists and clinicians alike, maintains the high standards set by its two predecessors. Particularly valuable is the chapter by Brown on oestrogens, for it not only provides a useful survey of their metabolism and clinical significance but it also gives full experimental details for their estimation in blood and urine in a form which is not readily available elsewhere. Folic acid and vitamin B_{12} are discussed in twin chapters by Girdwood and Grasbeck respectively, while the account of kernicterus by Arias includes a useful survey of present-day knowledge of bile pigment metabolism.

The chapter on flocculation tests in relation to liver disease by Reinhold is both exhaustive and critical in its treatment of a commonly employed procedure which is simple to carry out, but which has hitherto been difficult to explain in other than empirical terms. In striking contrast is the account of infra-red absorption analysis by Schwarz. While infra-red spectra are invaluable to the organic chemist in the identification of unknown compounds they have only recently come to be applied to the examination of tissue constituents and they are discussed here with particular reference to lipid analysis. Nevertheless, it is likely to be a long time before an infra-red spectrometer becomes a standard piece of equipment in every clinical chemistry laboratory, in Great Britain at least.

J. N. Davidson

Advances in Biological and Medical Physics

Vol. 7. Edited by Cornelius A. Tobias and John H. Lawrence. Assisted by Thomas L. Hayes. Pp. ix + 362. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1960.) 10 dollars.

THIS volume presents a further selection of seven topics from the wide field covered by this series.

First there is an excellent chapter by G. S. Stent and C. R. Fuerst on the genetic and physiological effects of the decay of phosphorus-32 following incorporation into bacterial viruses and bacteria. These effects are primarily the result either of the transmutation of phosphorus-32 to sulphur-32 or of the recoil of the nucleus and not to the ionization produced by the β-particle emission. There is a useful chapter on radiation effects on the nervous system by N. N. Livshits, covering much of the Russian literature in this field. Another chapter, by L. W. Law, on radiation carcinogenesis provides a wealth of data, but the discussion is confined almost exclusively to the mutational hypothesis for the induction of neoplasia. Confusion over dosage units leads to the incorrect statement that Wistar rats are 200 times more sensitive to phosphorus-32 than are CF_1 mice to strontium-90 for bone tumour induction. A chapter by D. Carlstrom deals with the technique of micro X-ray diffraction in biology, but only a few applications of the technique are described. There is a clear introduction

to autoradiography with tritium-labelled compounds by J. H. Taylor; however, important results on the damage to cells by so-called 'tracer' doses in experimental animals have appeared in the Press since the article was written. L. E. Lipetz provides a chapter on mechanisms for the transfer of information from the light image to the optic nerve in the horseshoe crab and D. Gitlin and C. A. Janeway deal with isotopic studies on the distribution and metabolism of plasma proteins.

In general, the authors have presented their subjects clearly and concisely, and the volume should provide a useful introduction to the various topics covered. N. M. BLACKETT

Radioactive Wastes

Their Treatment and Disposal. General Editor: J. C. Collins. Pp. xxi+239. (London: E. and F. N. Spon, Ltd., 1960.) 55s.

MR. COLLINS has brought together ten chapters, each written by an expert in his own field, which, together under one cover, form a logical and thorough treatment of a relatively new subject. Introductory chapters on the nature of radioactivity and sources of radioactive waste put the general problem in perspective. R. F. Farr's contribution on the hazards of radiation is a masterly summary. It takes account of dose-rate, total dose, external and internal irradiation, biological effectiveness of different radiations, the concentration of ingested isotopes in specific organs, and then shows how these factors are allowed for quantitatively in fixing maximum permissible levels of radioactive species in the body, in air, in drinking water, and on contaminated surfaces.

The law about disposal of radioactivity in Britain is summarized. The last five chapters describe techniques for meeting in practice the stringent standards which have been set for safe disposal of gaseous, liquid and solid radioactive wastes.

This is a technical book, full of factual information, but its very full glossary and index to abbreviations, combined with its logical style, should make it attractive to a very wide readership. It will be valuable to all those people who have responsibilities for public health, the husbanding of natural resources, nuclear power programmes and industrial use of radioactive materials. One feels that the book will be enjoyed also by those who read *Nature*, because they enjoy dipping into branches of science other than their own, and one hopes that through them this book may lead to well-informed discussion of a subject of importance to the general public.

K. D. B. JOHNSON

Digest of Literature on Dielectrics

Vol. 23, 1959. Edited by Louis J. Frisco and Thomas D. Callinan. (Publication No. 799.) Pp. xiv+423. (Washington, D.C.: National Academy of Sciences—National Research Council, 1960.) 8 dollars.

THE latest volume of this series comes up to the expected high level. The number of publications on the subject within a year is surprisingly large. There are 2,214 abstracts, and the origin of the papers is truly international.

In the measurement field, frequencies greater than 100 Mc./s. are coming into the forefront, and at the highest frequencies optical techniques attract increasing attention. A good deal of work is reported on dielectric properties and molecular structure. The chapter on conduction contains experimental results which are interpreted in terms of band theory, but conduction in good dielectrics still remains a difficult subject.

Breakdown in solids, liquids and gases has been reviewed systematically this year. At present there is interest in pre-breakdown currents, and relatively much work is reported on non-uniform fields.

In ferro-electricity and piezo-electricity one is impressed with the wide range of techniques used and the large Russian effort on the subject. The so-called relaxation dielectrics are attracting attention. The digest includes an impressive chapter on magnetism, with 528 references. Developments in this subject include new theoretical work on exchange forces and statistical mechanics and experimental work on thin films and devices.

The last third of the book is devoted to the technological application of insulating materials, and contains references to the patent literature. There is much interest in insulation for high temperatures.

In conclusion, the digest contains a complete bibliography of the subject, and the authors succeed in giving a fair critical appraisal of the papers abstracted. VERA DANIEL

Atlas of γ-Ray Spectra from Radiative Capture of Thermal Neutrons

By L. V. Groshev, V. N. Lutsenko, A. M. Demidov and V. I. Pelekhov. Translated from the Russian by J. B. Sykes. (International Series of Monographs on Nuclear Energy. Division 4: Isotopes and Radiation, Vol. 1.) Pp. iv+198. (London and New York: Pergamon Press, 1959.) 140s. net.

THE *Atlas*, which was first published in English in 1959, was the first attempt at an exhaustive compilation of information on thermal neutron capture γ-rays to be published in book form, though a rather similar compilation, not quite so comprehensive, was published as a Chalk River Report, *AECL*.669, by Bartholomew and Higgs in 1958. The work of the Russian group led by Groshev, in the field of neutron capture γ-rays, is too well known to require comment, and the *Atlas* contains much of their own work and that of the Chalk River Group, together with the relevant work published elsewhere up to and including 1958. The bibliography contains 97 entries.

The information presented begins with tables of stable isotopes giving isotopic abundances, thermal neutron capture cross-sections, spins and parities of target and product nuclei, and binding energies and half-lives of the product nuclei. The tables contain references to the original literature. Following the tables are the capture γ-ray spectra, together with further tables of intensities as measured by various authors, assignment, where possible, of the γ-rays to the appropriate compound nuclei, and also, where possible, energy-level diagrams.

This impressive compilation is invaluable both to the nuclear physicist and to the reactor engineer who is concerned with shielding problems. The only criticism of the book which I feel is justified concerns the technical matter of the reproduction of the figures. This appears to have been done rather hurriedly so that some of the curves are distorted and occasionally the lettering is difficult to read. Such technical defects seem out of place in a book costing £7. E. R. RAE

The Space Encyclopædia

A Guide to Astronomy and Space Research. Second, revised edition. Pp. 288. (Horsham: The Artemis Press, 1960.) 35*s*.

THE first edition of this fascinating work was published just before the launching of *Sputnik* 1. Much that was then mere speculation is now accomplished fact, and the many alterations in the new edition reflect the present rapid advance in space research. The section on "Artificial Satellites" has been completely re-written, with details of the 25 satellites and space probes launched prior to April 1960. The forty-odd new sections, ranging from "*Black Knight*" to "Van Allen Belts", have been added at the expense of certain minor topics and the condensation of others. In particular, several missiles hitherto treated separately are now collected under the new heading "Missile".

The appearance of the book is much improved by the addition of eight colour plates, one of which shows the beautiful "Veil Nebula in Cygnus". The famous Russian "Far side of the Moon" is one of several new photographs.

Certain misprints persist. In the Table of Planets, p. 230, the masses of Mars to Neptune are incorrect and on p. 155 the period of Phobos is still given as 7d. 39m. A curious mistake also occurs in the diagram on p. 28, where the track of *Sputnik* 1 is shown starting off south-east instead of north-east. These errors apart, the *Space Encyclopædia* will provide a useful reference to space enthusiasts for the next year or two, when we shall look forward to a further revised edition.

R. H. MERSON

Principles of Electricity and Magnetism

By Y. Rocard. Translated by G. F. Herrenden Harker. Pp. x+779. (London: Sir Isaac Pitman and Sons, Ltd., 1959.) 70*s*. net.

A NEW book in this field would need to be outstanding to make the task of translating worth while. The book is very up to date, and the many examples of the practical uses of the topics discussed bring new life into what is often regarded as a dull, text-book subject. Although the author advocates the use of rationalized M.K.S. units he in fact uses e.s.u., e.m.u., and practical units. The scope of the book is much wider than is implied by the title. Some sections have become so condensed that they have little value. The section on X-rays, which seems out of place in this volume, contains a number of mistakes (for example, it is suggested that a Laue photograph is obtained with a stationary crystal and *monochromatic* radiation, and, later, a powder diagram is described as a Laue photograph).

The Grenoble electrostatic generator is described in considerable detail, but no information is given about its performance. It is encouraging to see the permalloy magnetometers included in this type of book. The chapters on polyphase currents and d.c. machines are more complete than one expects in a book aimed at physicists rather than engineers. The notation throughout the book is not uniform. In Chapter 13 the Langevin formula is given and the symbols used are defined. In Chapter 31 the detailed theory is given using a different set of symbols. It is a pity, in a book designed for undergraduates, to find no problems for the students to solve.

E. STANLEY

Proceedings of the Institute of Petroleum Hydrocarbon Research Group Conference on Molecular Spectroscopy

Held in London, 27–28 February, 1958. Edited by E. Thornton and Dr. H. W. Thompson. Pp. vii+352. (London and New York: Pergamon Press, 1959.) 70*s*. net.

THIS report gives the twenty-two papers presented together with the relevant discussion at the second two-day conference on molecular spectroscopy held by the Hydrocarbon Research group. The contributors are from both industrial and academic laboratories in several countries, and are leaders in fields ranging from nuclear magnetic resonance through infra-red to ultra-violet spectroscopy, able to discuss with authority new ideas and techniques.

The range of topics presented is far from being confined to the petroleum field and will be of interest to every physical and organic chemist. The extent to which the conference is topical is demonstrated by the high proportion of space devoted to nuclear magnetic resonance spectroscopy and other new fields, for example, the applications of polarized infra-red radiation, shock-tube excitation and free-radical spectra. A range of papers shows advances in the infra-red region, including new instrumentation, theories of band intensities and the study of intermolecular forces in compressed gases, in surface adsorption, in solution and in the formation of hydrogen bonds.

The organizers of the conference are to be complimented on bringing this interesting diversity of speakers together. However, it does seem that the fields covered by the heading of "Molecular Spectroscopy" are rapidly becoming too numerous and too specialized to be covered adequately in a two-day meeting.

A. KNOWLES

A Mathematical Tool-Kit for Engineers

By H. A. Webb and Dr. D. G. Ashwell. Second edition. Pp. vii+116. (London: Longmans, Green and Co., Ltd., 1959.) 15*s*.

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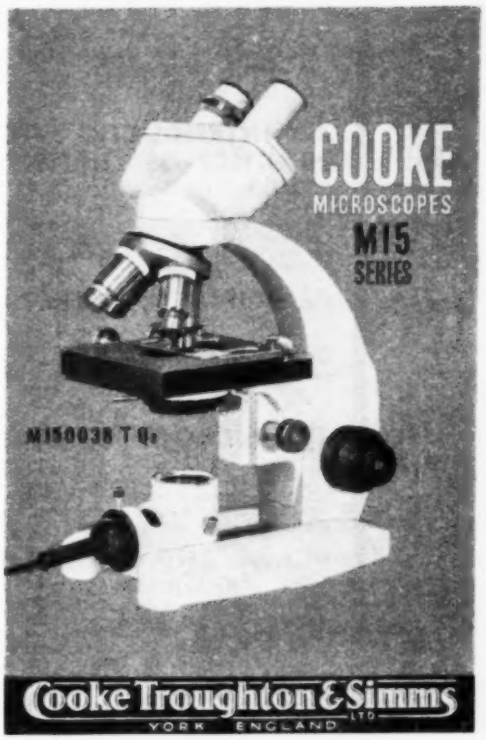

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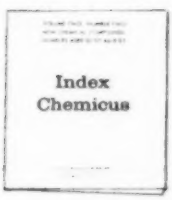

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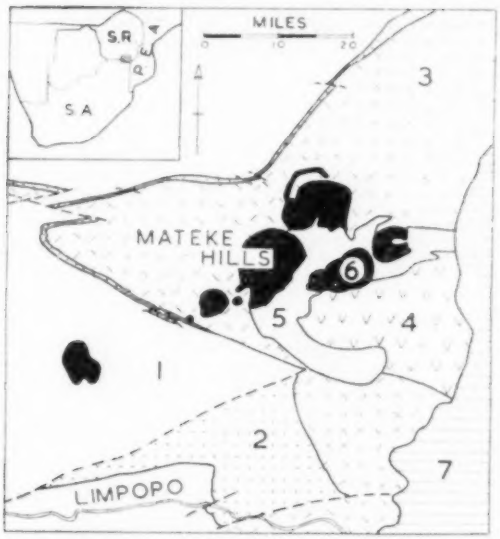

Fig. 1. Geological map of the Mateke Hills area in south-eastern Southern Rhodesia. Inset map: S.R., Southern Rhodesia; S.A., South Africa; P.E.A., Portuguese East Africa.

7.	Sediments	Cretaceous System
6.	Intrusive complexes	
5.	Main Granophyre	
4.	Rhyolites	Karroo System
3.	Basalts	
2.	Sediments	
1.	Gneisses, etc.	Basement Complex

Limpopo River. In contrast, neighbouring areas to the north and south are characterized by a very thin sequence of Karroo sediments which in places is absent altogether. Strong normal faulting developed along the sedimentary trough during the period of Karroo sedimentation.

A very much thicker volcanic sequence overlies the sediments and comprises a lower group of olivine basalts and tholeiites with associated picritic minor intrusives, and an upper group of ignimbrites of rhyolitic composition. A thick and extensive sill of granophyre, here termed the Main Granophyre, intrudes the volcanics near the base of the ignimbrite group.

The volcanic activity culminated with the development of eight intrusive complexes closely comparable with those found in Damaraland, South West Africa[2]. Six of the complexes lie in the vicinity of the Mateke Hills, Nuanetsi District, Southern Rhodesia, and have been mapped in detail. The alignment of most of the complexes along the Limpopo orogenic belt is a further demonstration of the importance of the belt in controlling Karroo geology.

Three of the complexes, of which the largest is the Northern Ring, consist of early gabbroic and later acid phases, the latter commonly being ring-intrusions. In the Northern Ring[3], an extensive layered gabbro series is exposed. The gabbroic intrusions are older than the Main Granophyre, while the acid ring-intrusions are younger. Most of the remaining complexes consist only of acid rocks, several phases of granitic and granophyric intrusion being present in each.

In the eastern part of the area, Cretaceous marine strata unconformably overlie the Karroo rocks, including the Main Granophyre. This is a strong indication that all the intrusive activity can be assigned to the late Karroo period.

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METALLURGY

Occurrence of an Ordered Phase in an As-Cast Titanium-Aluminium Alloy

Phase equilibria in the titanium-rich region of the titanium-aluminium constitution diagram have not been elucidated despite many experimental investigations. The results of earlier work[1] indicated an extensive region of hexagonal close-packed α solid solutions. At a temperature of 800° C. it was reported that 36·5 atomic per cent aluminium was soluble in the low-temperature modification of titanium. It was also concluded that the first intermediate phase on this side of the diagram was γ, which exists over a region of homogeneity and resulted from a pertectic reaction involving a β solid-solution and the melt. A study of the variation in lattice parameters as a function of composition in the proposed α phase region has been made[2]. Several papers have presented X-ray powder diffraction evidence for an intermediate phase in this same region of the diagram. This crystallographic species, the δ phase, has been observed in heat-treated specimens containing 25 and 33⅓ atomic per cent aluminium[3,4]. Experiments performed with an electron microscope[5] have demonstrated the epitaxial relationship of α and δ. A constitution diagram has been proposed[6] in which two intermediate phases exist between the terminal α phase and γ.

During an X-ray diffraction investigation of this region of the constitution diagram the δ phase has been observed in an as-cast alloy containing 37·1 atomic per cent aluminium. A fragment of an arc-melted ingot was examined and revealed Laue symmetry $6/mmm$. Weissenberg photographs of the zero and first layer lines were obtained with copper and molybdenum radiation. The diffraction maxima were sharp and doublets well resolved. Multiple-film techniques have been employed to obtain the structure factors. The unit cell content was placed in the following special positions of space-group D_{6h}^4: 2 aluminium atoms in (c), and a statistical distribution of titanium and aluminium atoms in the six-fold position (h). The compositional parameter associated with this configuration was assumed to be constant in the trial structure, and it was derived from the ingot composition. This assumption seems reasonable in view of the lattice parameter versus composition data[2] and the variation of structure factor with composition. Agreement of intensity measurements for strong and weak reflexions indicates a single crystal in object space. Previous papers reporting evidence for the δ phase derived their data

from heat-treated specimens. The fact that the δ phase has been found in an as-cast alloy would suggest that the proposed phase equilibria for this constitution diagram be given careful consideration.

A paper published by previous investigators[4] requires a comment. I established the similarity between X-ray powder diffraction photographs of Ti_3Sn and those of a titanium–aluminium alloy and a titanium–aluminium–vanadium alloy (Jaffee, L. D., to Margolin, H., private communication, September 29, 1955). The latter films had been obtained by other research workers in previous investigations at the California Institute of Technology Jet Propulsion Laboratory. These existing data were evaluated by me without prior knowledge that either a unit cell or indexing of maxima had been proposed for the δ phase. Furthermore, the necessity for consideration of composition and position parameters in the crystal structure determination of δ has been discussed in a private communication by myself to H. Margolin, October 25, 1955. I have neither demonstrated nor asserted that Ti_3Sn and Ti_3Al are isomorphous, as has been stated in the literature[4].

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CHEMISTRY

Oxidation of Galena to Lead Sulphate

Beveridge and Denbigh[1] have directed attention to the development of a concentric shell of zinc oxide when a compressed sphere of zinc sulphide powder was oxidized in air at 1,250° C. This shell was presumed to arise from the reaction between zinc and sulphur diffusing outwards from the surface of the zinc sulphide and oxygen diffusing inwards. The distance between the core and the shell increased with increasing temperature, and the diameter of the shell was greater than the diameter of the original core. During the oxidation of a crystal of galena (lead sulphide) to lead sulphate we have observed the formation of an approximately spherical product layer detached from and concentric with the galena crystal. The mechanism by which this product layer is formed appears to differ from that proposed for zinc oxide[1].

Using a thermobalance we have examined the rate of oxidation of discrete crystals of galena in an atmosphere containing oxygen, sulphur dioxide and nitrogen at temperatures from 700° to 800° C. Depending on the respective partial pressures of oxygen and sulphur dioxide, the oxidation product may be lead, lead oxide, mono-, di-, or tetra-basic lead sulphate, or lead sulphate[2]. In particular we have followed the formation of lead sulphate in oxidizing atmospheres containing 1–50 per cent oxygen and 1–50 per cent sulphur dioxide, the balance being nitrogen. The rate of oxidation has been calculated from the increase in weight of the sample observed over measured time-intervals. The galena crystals were not preheated in an inert gas before oxidation on account of the loss in weight from vaporization and oxidation to lead by traces of oxygen in the inert gas. Our results show that the oxidation proceeds as follows: Initially an adherent layer of lead sulphate builds up on the surface of the galena crystal; later this layer of lead sulphate becomes detached from the surface of the galena (leaving it free from oxidation products) and forms a brittle spherical envelope the dimensions of which approximate those of the original galena crystal; finally, cracks occur in the envelope as it progressively thickens and expands, and lead sulphate is again formed on the surface of the galena crystal. The composition of the product is confirmed by X-ray analysis.

Fig. 1. − 36 + 44 mesh galena crystals. *a*, Unoxidized; *b*, oxidized for 1 hr.; *c*, oxidized for 2 hr. Scale: 1 division = 0·5 mm.

Fig. 1*b* and *c* shows galena crystals which have been oxidized at 750° C. in an atmosphere containing 10 per cent oxygen, 15 per cent sulphur dioxide, and 75 per cent nitrogen. Several of the lead sulphate envelopes have been broken to reveal the partly reacted galena crystals.

In accounting for the development of the spherical envelope, we suggest that there is a gradual diminution in the permeability of the adherent layer of lead sulphate to the oxidizing atmosphere. Then following the vaporization of galena—with some dissociation into lead and sulphur[3]—a stage is reached where oxidation occurs predominantly by diffusion of lead and sulphur ions through the envelope to react

with the oxidizing atmosphere outside. Thus the envelope thickens, and, as the volume ratio of lead sulphate to lead sulphide is greater than unity, the resulting stresses cause the envelope to expand.

The rate of formation of the adherent layer of lead sulphate has been found to depend on the temperature and the sulphur dioxide content of the atmosphere; variations in the oxygen content, however, do not markedly affect the reaction-rate.

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Sodium Chloride Whiskers

It is generally believed that the fast and unidirectional growth of the major part of whiskers may be partly due to the winding up of one or more screw dislocations along the whisker axis[1]. S. Amelinckx demonstrated this dislocation mechanism in sodium chloride whiskers by the decoration technique[2]. He observed on whiskers grown by a simple method also the broadening of hollow, tube-like pyramids probably developed from spiral terraces which are thought to originate from axial screw dislocations[3].

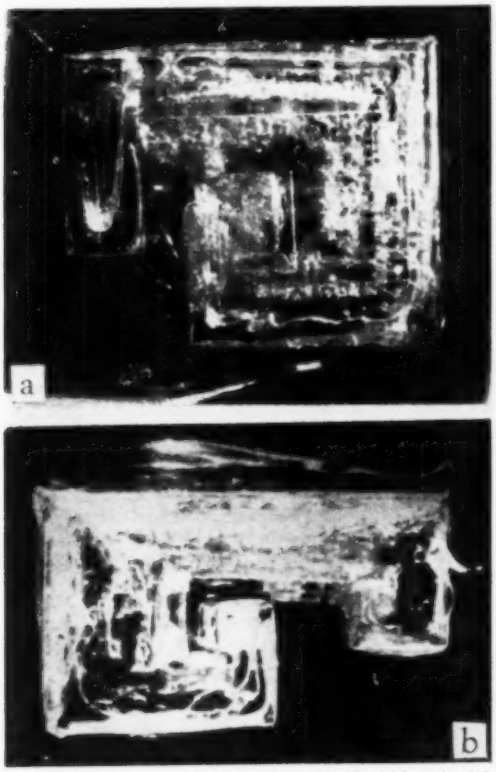

Fig. 1. Spiral terrace on the tip of sodium chloride whiskers. (× 10)

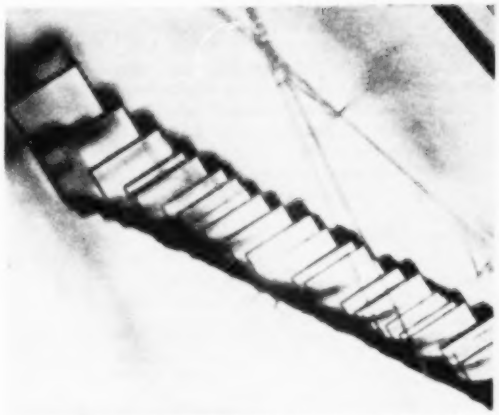

Fig. 2. A scale-like sodium chloride whisker. (× 150)

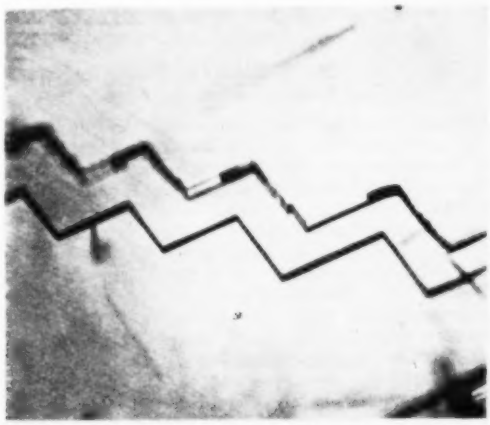

Fig. 3. A two-dimensionally twisted sodium chloride whisker. (× 150)

The pyramid growth pattern is known. V. D. Kusnezov suggested that its presence in crystals grown from solution may be related to the small dependence on temperature of the solubility of rock-salt[4]. The observations of Z. Gyulai refer to the growth of such pyramids from vapour[5]. We, too, found such 'troughs', not only on the tip of whiskers grown from vapour but also on sodium chloride plates exposed for some time to vapours of sodium chloride[6]. Hexagonal spiral-terrace patterns of N. A. Shamba and N. N. Sheftal on silicon crystals frozen from cooled melt, and observed easily with the optical microscope, are further examples[7].

We wish to report some interesting patterns obtained by growing sodium chloride whiskers from vapour. The pyramidal tip of the whiskers in Fig. 1(*a*) shows undoubtedly a spiral construction. The linear length of the pattern was 8 mm. Fig. 1(*b*) shows a similar whisker tip after the other parts of the pyramid were removed. The linear measurement of the spiral was in this case 6 mm.

Fig. 2 shows another example: it is suggested that this whisker with a scale-like construction refers to spirals[8].

The zig-zag pattern in Fig. 3 indicates that the two-dimensional explanation of S. Amelinckx[9] of the helically twisted silver whiskers observed by Brenner[10] refers to a two-dimensionally twisted whisker shape which actually exists.

We wish to thank Miss F. Jost for her help.

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Effect of Strong Electric Fields on the Boiling Points of some Alcohols

While investigating the molecular theory of liquids and liquid mixtures we were led to examine the effect of strong electric fields on the saturation vapour pressures (boiling points) of liquids. Results of these investigations for methyl, ethyl and *iso*propyl alcohols are reported here.

The liquid is in a cylindrical tube about 20 cm. long which is immersed in a transformer oil bath. A condenser, fitted to the side of the tube through a ground-glass joint, keeps the boiling liquid in contact with the outside atmosphere while at the same time vapours condense and flow back into the liquid without escaping out of the apparatus. A Beckmann thermometer, graduated in hundredths of a degree centigrade, is inserted from the upper end of the tube and held vertical with its bulb just above the surface of the boiling liquid. When the liquid is boiling the bulb remains completely covered with a continuous film of the liquid formed by the condensing vapours which trickle back into the liquid in the form of drops. A built-in condenser is provided near the upper end of the tube to prevent any possible leakage of vapours through the upper portion. A regulated supply of heat to the oil bath is given by an electric heater controlled by a 'Variac' transformer. The temperature of the oil bath is maintained a few degrees above the boiling point of the liquid. Under these conditions the boiling point could be maintained constant to 0·01 deg. C. for fairly long intervals.

The tube containing the boiling liquid and its vapours is held between two parallel metal plates to which an alternating voltage of about 20 kV. can be applied through a transformer.

Samples of pure specimens used in the present investigations were Merck's analytical reagents from freshly opened bottles which were further purified by the usual methods until their boiling points and densities agreed with those quoted in the literature. The liquid was allowed to boil first in the absence of the field, and after the temperature remained steady for about ½ hr. the field was switched on. The temperature starts falling almost immediately and becomes steady after some time. On switching off the field the boiling points rose to their original values.

The depression in the boiling points, ΔT, for fields E, varying from 0 to 5 kV./cm., were determined for methanol, ethanol and *iso*propanol.

Observations were also made with three different tubes A, B and C of diameters 3·65 cm., 3·00 cm. and 2·50 cm. respectively. These are shown in Table 1.

Table 1. Depressions in the Boiling Points of Methanol Ethanol and *Iso*propanol in Electric Fields

Applied voltage (kV./cm.)	ΔT (° C.)								
	Methanol			Ethanol			*Iso*propanol		
	A	*B*	*C*	*A*	*B*	*C*	*A*	*B*	*C*
0·00	0	0	0	0	0	0	0	0	0
2·36	0·68	0·70	0·80	—	—	—	—	—	—
2·89	1·05	1·08	1·10	0·32	0·34	0·35	—	—	—
3·42	1·25	1·29	1·40	0·40	0·43	0·45	0·20	0·20	0·23
4·00	1·80	1·87	1·90	0·60	0·65	0·64	0·25	0·26	0·26
5·00	2·00	2·00	2·10	0·70	0·72	0·76	0·40	0·42	0·42

However, when the field was applied only to the liquid region and not to the vapour phase, a rise of 0·1 deg. C. was observed in the case of methanol at 5 kV./cm.

Observations with other polar as well as non-polar liquids are in progress.

We wish to thank Prof. D. S. Kothari for suggesting the problem and helpful discussions. One of us (M. M. C.) is grateful to the Council for Scientific and Industrial Research for financial assistance.

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Thermo-Reversible Denaturation of Eucollagen in Solution

A substantial proportion of mature collagenous tissue will dissolve in weakly acidic media after a cold pre-treatment in alkali. The resulting solutions of soluble eucollagen show qualitatively many of the characteristics of solutions of acid-soluble collagens[1]. In particular, a very dilute solution in 0·15 M citrate (pH 3·7) possesses a high specific viscosity (η_{sp}/C about 10 dl./gm. at C = 0·02 gm./100 ml.) over the temperature range 5–25° C., and a very much lower value (η_{sp}/C about 0·4 dl./gm.) at 35° C. and higher temperatures. The high viscosity at low temperatures suggests that eucollagen, like collagen, has a rigid, rod-like form in solution, while the relatively low viscosity at 35° C. and higher temperatures reflects the very flexible nature of the gelatin molecules which are formed rapidly and irreversibly under such conditions from the eucollagen solution.

At intermediate temperatures (for example, 30° C.) the initially high viscosity falls with time, and on re-cooling to 20° C., the solution shows a marked and rapid rise in viscosity. Examples are given in Fig. 1. Boedtker and Doty[2] have stated that solutions of soluble collagen, after partial denaturation by heating, show an increase in viscosity on re-cooling, and have suggested that this is due to aggregation of the gelatin molecules previously formed

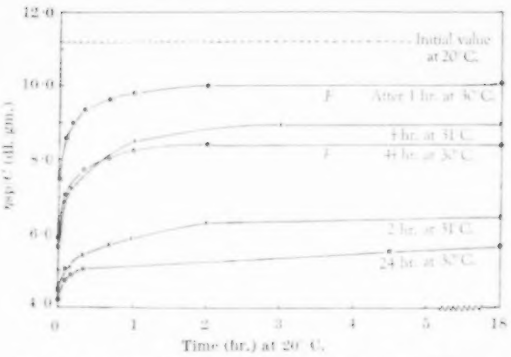

Fig. 1. The time dependence of η_{sp}/C at 20° C. for eucollagen solutions which have been heated at 30° or 31° C. for the times stated. Concentration, $C = 0{\cdot}05$ gm. eucollagen per 100 ml. 0·15 *M* citrate (*p*H 3·7). Eucollagen prepared from demineralized bone

at the higher temperature. However, if this were the explanation of the present results, the viscosity should increase with time only slowly in the initial stages, at 20° C., more rapid increases following as larger and larger aggregates are built. Fig. 1 shows clearly that the rate of rise decreases with time. Moreover, the maximum possible contribution to the viscosity from aggregation of derived gelatin is far smaller than the observed changes in the viscosity of soluble eucollagen at 20° C. after a period at 30° C. This is confirmed (Fig. 2) by observing the aggregation in eucollagen solutions which have been completely denatured by heating at 60° C. for 10 min. Thus the recovery in viscosity at 20° C., after partial denaturation at 30° or 31° C., can be due to gelatin aggregation only to a minor extent.

It is therefore presumed that the structural disorganization on heating eucollagen in solution at 30 or 31° C. proceeds in two steps, the first of which is, at least, partially reversible by cooling, while the second gives rise irreversibly to gelatin. The partially disorganized, thermo-reversible states for dissolved eucollagen have considerable stability at 30° C. (Fig. 1). At higher temperatures, however, the life-time of any intermediate state is short, so that the conversion of eucollagen to gelatin proceeds in effect in only one step.

Exploratory experiments have shown that fibrils are formed from incompletely denatured eucollagen solutions re-cooled to 20° C. and dialysed against 1 per cent sodium chloride. (The solutions used are

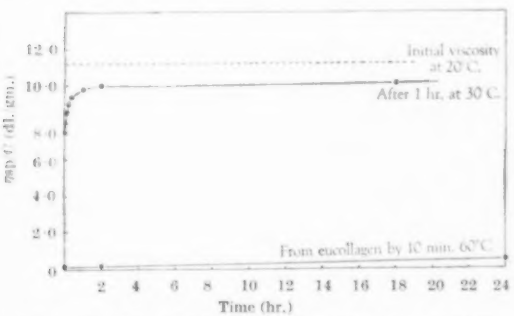

Fig. 2. The time dependence of η_{sp}/C at 20° C. for a partially and a completely denatured eucollagen solution, in 0·15 *M* citrate (*p*H 3·7)

marked *F* in Fig. 1.) Such fibrils have a shrinkage temperature 5–10 deg. C. less than the value for fibrils prepared from a sample of the original, undenatured solution. The formation of fibrils from the denatured solutions could arise either from eucollagen particles which were unaffected by the higher temperature, or from particles re-organized from intermediate states formed on heating. The observed fall in shrinkage temperature suggests that the latter particles are an important constituent.

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Reductive Dimerization of Naphthalene by Sodium–Ethylamine

Benkeser *et al.* have reported[1] that naphthalene is reduced to octalin and decalin by lithium–ethylamine; however, sodium–ethylamine was said to convert naphthalene to unidentified polymeric materials. Because of our interest in the reduction of organic compounds and of coal by metal–amine systems[2], we have re-investigated the naphthalene–sodium–ethylamine reaction. The so-called polymeric material has been identified as a stereoisomer of 1,2,3,4,1′,2′,3′,4′-octahydro-2,2′-dinaphthyl, (I).

A mixture of 6·40 gm. of naphthalene, 10·35 gm. of sodium, and 200 gm. of ethylamine was refluxed for 5½ hr. Ether was added, the solution decanted from a large amount of unreacted sodium, and the product washed, dried and distilled. There was obtained 3·73 gm. of material, b.p. 180–200° (2–3 mm.), which slowly crystallized. The low-voltage mass spectrum showed mass 132 (tetralin), 260 (hexahydrodinaphthyl) and 262 (octahydrodinaphthyl). Three recrystallizations from ethanol gave 1·70 gm. of white crystals, m.p. 84·0–85·0°, mass 262. Anal. calcd. for $C_{20}H_{22}$: C, 91·55; H, 8·45; found: C, 91·38; H, 8·43. This purified material was used to calibrate the mass spectrometer, and the assumption was made that the instrument would have the same sensitivity for the hexahydrodinaphthyl as for the octahydrodinaphthyl. On this basis the original reaction product contained: tetralin, 9 per cent; hexahydrodinaphthyl, 19 per cent; octahydrodinaphthyl, 72 per cent. Dehydrogenation of the octahydrodinaphthyl (palladium-on-charcoal, 330–355°) gave 2,2′-dinaphthyl, identified by melting point and infra-red spectrum.

Only three structures (I, II, III) can be written for an octahydro-2,2′-dinaphthyl if it is assumed that each nucleus contains a benzene ring. The ultra-violet absorption spectrum (peaks at 2732 Å., E = 1417 and at 2660 Å., E = 1241; shoulder at 2615 Å., E = 893) of the hydrocarbon described here elimin-

ates the structure (III), which would have a spectrum similar to that of diphenyl[3]. The structure (II) is eliminated because it contains a 1,2,4-substituted benzene ring, which would be expected to have the long wave-length band at about 2790 Å. (ref. 4). Since (I) consists of two tetralin nuclei it should have peaks at positions almost identical with those of tetralin, with about twice the intensity of the tetralin peaks. For comparison, values for tetralin are 2734 Å., $E = 625$; 2662 Å., $E = 537$; 2618 Å., $E = 370$.

The structure (I) was substantiated by dichromate oxidation of the hydrocarbon, which gave only phthalic acid; by nuclear magnetic resonance spectroscopy (aliphatic H/aromatic H, calcd., 1·75; found, 1·8; aliphatic H_α/aliphatic H_β, calcd., 1·33; found, 1·4); and by the infra-red spectrum (absorption maxima at 5·15, 5·22, 5·30, 5·45, 5·53, 5·57, 12·25, 13·36 and 13·52μ) which is consistent only with (I) (ref. 5).

The structure (I) could exist in both a meso and a racemic form, but only one compound was actually isolated; hence some step in the reaction sequence which fixes the configuration of the product must be stereospecific.

The reaction is under investigation to find other systems which will give dimeric products. Anthracene and phenanthrene have been reduced, but no dinuclear materials have been found. It is of interest that electrolytic reduction of phenanthrene yields 9,10,9′,10′-tetrahydro-9,9′-diphenanthryl, but no dinuclear product is obtained by electrolytic reduction of naphthalene[6]. On the other hand, we have found (Sternberg, H. W., Delle Donne, C. L., Reggel, L., and Wender, I., unpublished work) that lithium–ethylenediamine reduction of naphthalene at 15° gives about 30 per cent of dimeric reduction products, the structures of which have not yet been determined.

We wish to thank Dr. R. A. Friedel for the spectroscopic studies.

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Ionization Potential and Molecular Complex of Benzothiazol with Iodine

The three aromatic molecules benzophenone, indol and benzothiazol should act as electron donors and, as such, should favour the formation of molecular complexes with electron acceptors such as the halogens[1]. A spectroscopic investigation of such a possible effect between these molecules and iodine was therefore undertaken and we briefly report the results here.

For benzophenone and indol, no changes in the spectra of solutions of these compounds were noticed when adding iodine (solvents were *n*-hexane for indol, and carbon tetrachloride for benzophenone), and neither any colour modification of the iodine solution nor new absorption in the ultra-violet region was observed. No complex thus seems to be formed between benzophenone or indol and iodine; at least none is detectable under the conditions of our experiments.

On the contrary, in the case of a solution of benzothiazol in carbon tetrachloride, a slight colour modification of the iodine solution was noticed when properly chosen proportions of benzothiazol and iodine were used (about 30 times more benzothiazol than iodine). The 517-mμ absorption maximum characteristic of iodine is practically not shifted (new maximum at 516 mμ), but a new absorption occurs in the near ultra-violet region around 300 mμ, as observed with a Zeiss spectrophotometer. Using a Beckman automatic *DK* II spectrophotometer, a new and intense ultra-violet absorption band characteristic of a new compound was observed at 282 mμ. Its intensity is about that of the usual high ultra-violet absorption of molecular complexes, and may perhaps be ascribed to a charge-transfer phenomenon.

It is well known that charge-transfer maxima are closely related to ionization potentials and a simple expression for this relation has been proposed[2]. A curve relating ionization potentials and ultra-violet charge-transfer maxima was published recently[3]; from this it is possible to deduce an ionization potential for benzothiazol.

It is found in this way that the 282 mμ maximum corresponds to an ionization potential of 8·65 V. for benzothiazol. This is considerably lower than the ionization potential of benzene[4], but closer to the ionization potentials of pyrrole[5] and thiophene[5], and might indicate that it corresponds to the removal of a non-bonding electron from either the nitrogen or sulphur atom, rather than a π-electron of the benzenic system.

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BIOCHEMISTRY

In vivo Formation of Normorphine in the Rat as a Metabolite of Tritium Nuclear-labelled Morphine

Evidence for the N-demethylation of morphine has been provided by the demonstration *in vivo* of the pulmonary excretion[1,2] of carbon-14 labelled carbon dioxide from morphine-N-methyl-^{14}C and *in vitro*[3,4] by the enzymatic liberation of formaldehyde. The formation of normorphine *in vivo* has not been demonstrated directly, principally because of the low sensitivity and poor specificity of procedures used. The recent preparation of tritium nuclear-labelled

morphine[5] has provided the means by which the *in vivo* formation of normorphine from morphine could be observed in a sensitive and specific manner using selective paper chromatography.

Male rats (Sprague–Dawley strain) were injected subcutaneously with tritium nuclear-labelled morphine sulphate (10 mgm./kgm., as free base) and the urine was cage-collected for 48 hr. under toluene. The urine was autoclaved with 1/10 volume of concentrated hydrochloric acid for 25 min. at 18 lb. pressure, cooled, neutralized with sodium hydroxide solution to *p*H 9, and buffered with phosphate buffer, *p*H 10·3. An appropriate amount of cold normorphine was added as carrier, and the solution saturated with solid sodium chloride and extracted by shaking for 45 min. with ethylene dichloride containing 30 per cent *n*-amyl alcohol. The organic layer was separated and the aqueous phase re-extracted with fresh organic solvent. The residue, obtained by evaporation of pooled organic solvent extracts, was dissolved in absolute methanol and the solution chromatographed (descending) on a large Whatman No. 3 *MM* sheet using *n*-butanol, acetic acid and water (4 : 1 : 2, by volume) as the solvent system. A narrow guide strip from the chromatogram was scanned for radioactivity by elution of 1-cm. strips with dilute hydrochloric acid, the eluates being transferred to individual counting vials and evaporated to dryness. The residues were dissolved in absolute methanol, phosphor solution was added, and the samples were counted in a liquid scintillation Packard 'Tri-Carb' spectrometer. The scan revealed a single sharp peak of radioactivity (R_F 0·57). The area under this peak was cut from the rest of the chromatogram, eluted repeatedly using hot absolute methanol, and the eluate concentrated to a small volume and chromatographed on Whatman 3 *MM* paper strips, buffered with 0·2 *M* phosphate buffer (*p*H 8) using *tert.*-amyl alcohol, *n*-butyl ether and water (80 : 7 : 13, by volume) as a solvent system. The scanning of a guide-strip resolved the single peak of the previous chromatogram into two peaks of radioactivity, one of R_F 0·76, due to tritium-labelled morphine, and the other of R_F 0·20.

The area under the peak of R_F 0·20 was eluted with hot absolute methanol and chromatographed on Whatman 3 *MM* paper strips with *n*-butanol, acetic acid and water (4 : 1 : 2). Scanning the chromatogram revealed a major sharp peak of radioactivity at R_F 0·57 coinciding with cold normorphine on co-chromatography. A small broad peak with R_F 0·39–0·51 which produced a diazoblue colour reaction (50 mgm. tetrazotized diorthoanisidine dissolved in 15 ml. of 0·2 *M* phosphate buffer *p*H 9 ; purchased from Dajac Laboratories as Naphthanil Blue *B*) and another very small peak at R_F 0·82 also appeared in this chromatogram. The identity of the compound giving the peak of radioactivity at R_F 0·57 was further confirmed by co-chromatography with cold normorphine on Whatman 3 *MM* paper strips buffered at *p*H 8·9. The R_F of the radioactive peak was 0·18, and identical with the R_F obtained by spraying with diazoblue reagent. Some radioactivity also appeared at the origin of this chromatogram and in a small broad band at R_F 0·37–0·49.

Adequate chromatographic controls ensured the absence of normorphine in injected drug and the possibility of chemical artefacts resulting from the extraction procedures.

Direct chromatography of urine from a second group of rats, injected as described previously, on large Whatman 3 *MM* sheets using *n*-butanol, acetic acid and water (4 : 1 : 2) showed two areas of radioactivity, one having broad-band R_F 0·027–0·19 (probably due to conjugated morphine and conjugated metabolites) and another with R_F 0·67–0·72 (probably due to free morphine and free metabolites). The two areas were manipulated separately. Acid eluate from the area having R_F 0·67–0·72 was extracted as before, using cold normorphine as carrier. The residue obtained by the evaporation of the organic phase was dissolved in absolute methanol, chromatographed as described on Whatman 3 *MM* paper strips buffered at *p*H 8·0 and 9·3. Known cold normorphine gave identical R_F values.

Similarly, the area having R_F 0·027–0·19 was eluted, the eluate autoclaved and treated as described to give similar results. Evidence was obtained that normorphine was also present in conjugated form as a metabolite. A detailed report will appear elsewhere.

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Denaturation of Catalase by Freezing and Thawing

The effects of freezing and thawing on the structural and functional integrity of various biological materials, for example tissue, red blood cells[1], spermatozoa[2] and mitochondria[3], have received increasing attention recently, especially from the point of view of low-temperature storage. At the level of isolated enzyme proteins, investigations[4,5] have been qualitative in nature.

This communication deals with the fundamental aspects of the effects of freezing and thawing on the biochemical activities of fresh ox liver catalase. (Catalase became completely resistant against freezing and thawing denaturation after several months storage in solution (*p*H 7·0) or crystalline states in a refrigerator.) In our experiments, 0·5-ml. samples of *M*/100-buffered catalase solution (0·8 μgm./ml.) in test-tubes (1·0 cm. × 10·0 cm.) were frozen by immersion in a bath set to each required low temperature. After a given time the solution was removed and thawed rapidly in a bath at 25° C. After suitable dilution the remaining activity was determined in *M*/75 phosphate buffer, *p*H 7·0, at 0° C.

Partial inactivation of catalase occurred within 10 min. after immersion and then its activity remained constant during the next few hours. The extent of this inactivation depended on various experimental conditions, such as freezing temperature, enzyme concentration, and *p*H of the enzyme

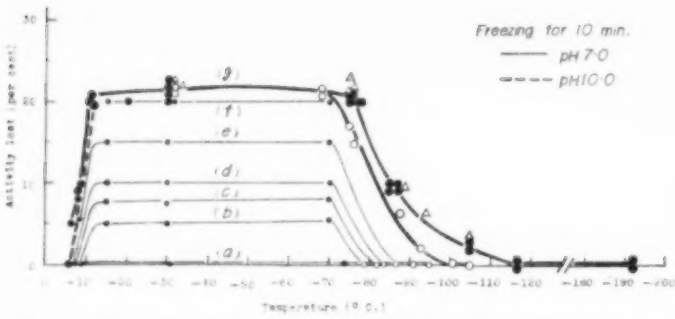

Fig. 1. Activity lost when catalase solutions containing various solutes are frozen. In all experiments the enzyme was frozen in *M*/100 phosphate buffer at *p*H 7·0 (except for *p*H 10·0 indicated by a broken line), for 10 min. by immersion at the temperature indicated, directly (●), or transferred from pre-freezing at −192° C. (○), or by an air jacket (△). Catalase concentration: $8{\cdot}4 \times 10^{-3}$ mgm. dry weight/ml.
Curve (*a*) illustrates the protective action of 0·01 per cent gelatin; (*b*) 0·5–1·0 *M* glycerol; (*c*) 1 *M* glucose, 0·1 *M* sodium acetate, ammonium sulphate, sodium butylate, sodium caprylate; (*d*) 5×10^{-4} *M* sodium dodecyl sulphate; (*e*) 1 *M* sucrose; 2·5 *M* ethylene glycol; (*f*) 0·01 per cent ovalbumin; (*g*) no additive

solution. Concentrated enzyme solution was more resistant against freezing inactivation. The activity lost – freezing temperature curve (Fig. 1) indicates that there is a temperature-range in which catalase is denatured during freezing and thawing. The inactivation of catalase by freezing commenced at about − 6° C., then reached the 20 per cent level at − 12° C., remained at this level to near − 75° C., and at last was reduced gradually between −75° C. and −120° C.; and over the range from −120° C. to −192° C., catalase solutions retained their activities completely against freezing and thawing.

The upper boundary of this critical region depends on the initial *p*H of freezing solutions. At −6·5° C. no damage occurred at *p*H 10·0, but the increasing damage occurred on either side[6]. At temperatures below −12° C., however, no dependence on *p*H was observed (*p*H range 5–11). The lower boundary, on the other hand, seems to be connected with the cooling-rate. Some shifting of this inactivation curve has been demonstrated under three conditions (Fig. 1); first, test-tubes were immersed directly into low-temperature baths; secondly, they were immersed with air jacket by placing them in larger tubes; and thirdly, they were frozen rapidly to −192° C., and then transferred to the required low-temperature bath.

It is interesting that even if catalase solutions are transferred to −30° C. after pre-freezing at −6·5° C. (*p*H 10·0) or at −192° C. without inactivation, they both suffer 20 per cent inactivation of activity within 10 min., which completely coincides with the level of inactivation by freezing directly in −30° C. bath for 10 min. This strongly suggests that the denaturation of the enzyme by freezing and thawing may be caused by the transition processes of the ice-crystal state responsible for the critical region of temperature, whether from the liquid state or from the frozen state outside the above range.

It was of interest to investigate whether glycerol and ethylene glycol, which have attracted increasing attention recently as 'antifreezer'[1,2], provided protective action against denaturation of catalase by freezing and thawing. In addition, some sugars, inorganic electrolytes, fatty acids (which have been known to inhibit the denaturation of some proteins) and other substances of interest were also tested (Fig. 1).

The results of these observations show the considerable protective action of 1 *M* glycerol, 1 *M* glucose, 0·1 *M* sodium acetate, 0·1 *M* ammonium sulphate, 0·1 *M* sodium butyrate, 0·1 *M* sodium caprylate, and also 5×10^{-4} *M* sodium dodecyl sulphate. Gelatin gave complete protective action over the whole temperature region in a low concentration of 0·01 per cent, but the same concentration of ovalbumin had little effect.

Our present knowledge is insufficient to give an experimental explanation for the existence of our critical region of temperature. However, it is interesting to compare these results with the analogous phenomena which Lovelock[1] reported on the haemolysis of human red blood cells by freezing and thawing.

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Assay of Pyridine Nucleotide Coenzymes and Associated Dehydrogenases with Phenazine Methosulphate

SINCE the original application of phenazine methosulphate to the assay of soluble succinic dehydrogenase by Singer and Kearney[1], this useful reagent has been increasingly employed as a carrier in a number of histochemical techniques[2,3].

Recent announcements of the use of the dye colorimetrically, coupled to 2 : 6-dichlorophenol indophenol, for the assay of certain soluble pyridine nucleotide-linked enzymes[4], and for the oxidative decarboxylation of pyruvate[5], prompts the publication of a manometric assay method, which has been in use in this laboratory for some time, employing phenazine methosulphate to measure di- and triphosphopyridine nucleotide-linked dehydrogenases in connective tissue. As the method described can be used for particulate as well as for soluble dehydrogenases a short account of its use is given here. Full details of theoretical and practical considerations will be reported elsewhere.

It has been found that the aerobic oxidation of reduced pyridine nucleotide coenzymes can be made to proceed stoichiometrically via the autoxidation of phenazine methosulphate in the Warburg apparatus. This is illustrated for the case of reduced

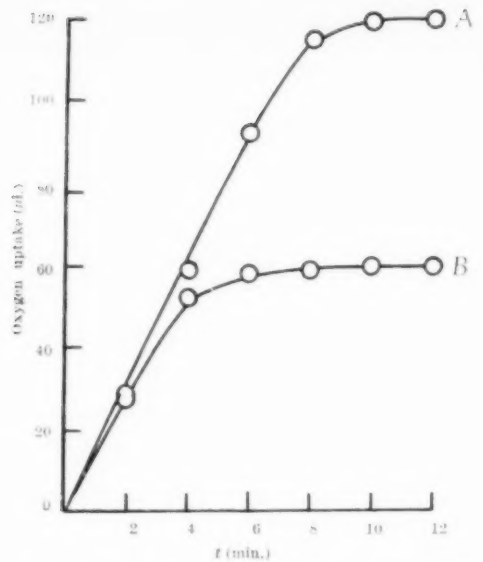

Fig. 1. Oxidation of DPNH by phenazine methosulphate. Warburg flasks contained: 2·45 ml. phosphate buffer, 0·1 *M*, *p*H 7·3; 0·1 ml. phenazine methosulphate, 10 mgm./ml.; 0·25 ml. DPNH (83 per cent by optical assay), in side-arm. *A*, 7 µmoles; *B*, 3·5 µmoles; water to 3·0 ml. Flasks tipped at zero time. Temperature, 29°. Gas phase air

diphosphopyridine nucleotide (DPNH) in Fig. 1. Experimentally, it applies equally to reduced triphosphopyridine nucleotide (TPNH). The amount of reduced coenzyme originally present in a test sample can be ascertained from the total oxygen consumption, and the fact that one mole of reduced coenzyme per mole of oxygen participates in the reaction. Added diaphorase is without effect on either the rate or extent of the oxygen uptake.

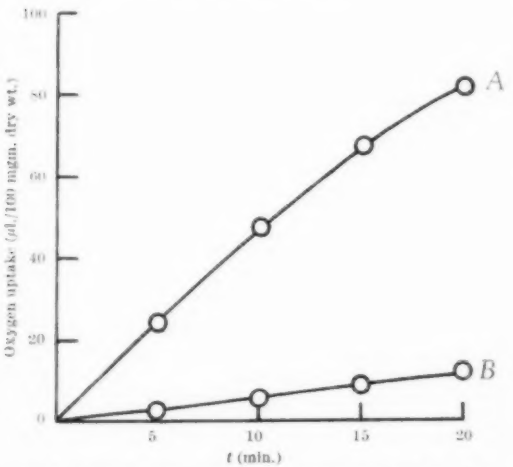

Fig. 2. Glucose 6-phosphate dehydrogenase activity in experimentally treated rabbit synovial tissue pulp. Warburg flasks contained: 1·7 ml. phosphate buffer, 0·1 *M*, *p*H 7·3; 0·1 ml. phenazine methosulphate, 10g mm./ml.; 0·2 ml. D-glucose 6-phosphate (25 m*M*); 0·2 ml. TPN, 15 mgm./ml.; 0·1 ml. cyanide (0·1 *M*); 0·2 ml. 10 per cent potassium hydroxide (in centre well); 0·5 ml. tissue. *A*, Complete system; *B*, minus D-glucose 6-phosphate. Substrate, TPN and phenazine methosulphate in side-arm; tipped after equilibration. Temperature, 37°. Gas phase air

From these and other observations it appears that, in a similar fashion, reduction of pyridine nucleotide coenzyme also can be followed. Dehydrogenase activity of a chosen tissue in the presence of suitable substrate and coenzyme can be compared with the endogenous activity of the same tissue with or without addition of inhibitors. Lately, the dehydrogenases of both pulped and intact connective tissue preparations from the region of joints have been studied in this manner and, to choose one example, Fig. 2 shows the D-glucose 6-phosphate dehydrogenase activity of a pulp-preparation of synovial tissue from experimentally treated rabbits. Cytochrome oxidase and catalase, if present, are inhibited by use of cyanide in the incubation mixture[6]. This extension of the Singer and Kearney method for succinic dehydrogenase to pyridine nucleotide-linked enzymes may therefore find application in situations where, by the nature of the tissue, optical or colorimetric assays are precluded.

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Hormonal Induction of Alkaline Phosphatase in Human Cells in Tissue Culture

During an investigation of differences between established lines of human cells in culture, the alkaline phosphatase content was found to vary from high activity in certain epithelial lines to trace or no detectable activity in other epithelial lines. In a series of six HeLa lines the variation in alkaline phosphatase was as great as among cell lines derived from other tissues and from different species. Among the six lines of uncloned HeLa cells four showed marked 'constitutive' alkaline phosphatase activity and two showed trace or no activity (Table 1).

The human origin of the HeLa lines was established by their poliovirus susceptibility, immunological properties and chromosomal morphology[1].

Table 1. Phosphatase Activity of Six HeLa Cell Lines

HeLa cell line	Alkaline phosphatase*	Acid phosphatase*	Source of cultures
MBA	0·50	0·06	Microbiological Associates, Bethesda, Md.†
A_{72}	0·58	0·10	Merck, Sharpe and Dohme, West Point, Pa.
K	0·12	0·08	Dr. M. Kline, Philadelphia, Pa.†
G	0·41	0·09	Dr. H. Ginsberg, Philadelphia, Pa.
Henle	<0·01	0·10	Dr. W. Henle, Philadelphia, Pa.
NIH	<0·01	0·08	Miss M. Levy, Bethesda, Maryland†

* Mgm. of phenolphthalein released by a deoxycholate lysate containing two million cells. Incubation with substrate was for 2 hr. (ref. 5) at 37° C.

† Furnished by Dr. L. Coriell, Southern New Jersey Research Institute, Camden, N.J., who had propagated these lines in his laboratory for more than a year.

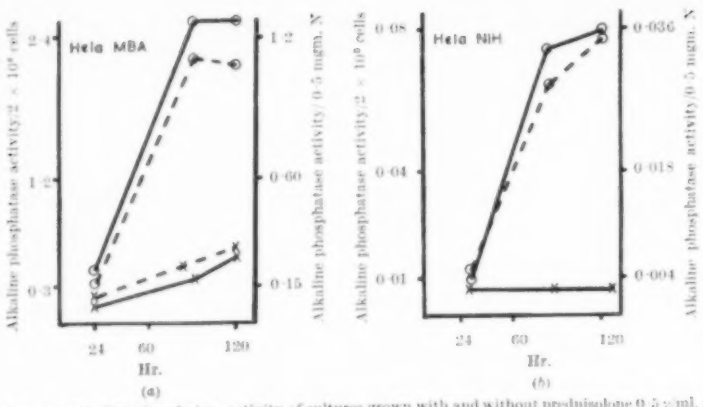

Fig. 1. Alkaline phosphatase activity of cultures grown with and without prednisolone 0·5 γ/ml.: (*a*), HeLa MBA, an example of a strain with 'constitutive' activity rising about 8-fold with prednisolone induction; (*b*), HeLa NIH, an example of a strain without detectable 'constitutive' alkaline phosphatase which develops activity by prednisolone induction. ×, without prednisolone; ○, with prednisolone. Solid line, alkaline phosphatase activity per 2 million cells; broken line, alkaline phosphatase activity per 0·5 mgm. nitrogen

Alkaline phosphatase synthesis is known to be of the inducible type in micro-organisms[2], in explants of avian and mammalian embryonic tissue[3], and in human leucocytes *in vivo*[4]. It is of particular interest that adrenal glucocorticoids induce alkaline phosphatase activity in embryonic intestinal epithelium of chicks and mice earlier than it normally appears during development.

Two HeLa lines (Henle and NIH) contain trace or no detectable alkaline phosphatase unless grown in medium containing prednisolone (Δ' hydrocortisone) 0·5 γ/ml. In the presence of prednisolone these otherwise 'negative' lines developed as much as one-fourth the alkaline phosphatase activity usual in the other four lines. Either prednisolone hemisuccinate or prednisolone phosphate was equally effective as inducer. Most but not all epithelial cell lines with high constitutive alkaline phosphatase show an increase in enzyme when cultivated in medium with added prednisolone. We are preparing a report on the effects of prednisolone on different cell lines.

In addition to inducing alkaline phosphatase, prednisolone has a number of other effects on human epithelial cell lines. It reduces cell multiplication by about 40 per cent; it causes an increase in epithelial cell cytoplasm with almost a doubling of cell volume and a 30–50 per cent increase in cell protein. In epithelial cells grown in the presence of prednisolone, acid phosphatase activity remains constant per unit of cell nitrogen. On the other hand, alkaline phosphatase activity of inducible lines increases markedly.

Table 2 presents the result of experiments on three HeLa lines. One of these, MBA, has constitutive alkaline phosphatase and the two others, Henle and NIH, have trace or no detectable activity unless grown in medium with added prednisolone. Within each experiment all cultures were replicate and were handled similarly except for the addition of prednisolone 0·5 γ/ml. to the experimental cultures. As shown in Table 2, alkaline phosphatase activity is increased in cultures grown in medium with prednisolone whereas acid phosphatase is not significantly altered when expressed on the basis of cell nitrogen.

Table 2. Increase in Alkaline Phosphatase Activity of Cells grown with Prednisolone added

HeLa cell lines	No. of experiments	Cells (2×10^6) grown without prednisolone			Cells (2×10^6) grown with prednisolone		
		Alkaline phosphatase*	Acid phosphatase*	Protein N†	Alkaline phosphatase*	Acid phosphatase*	Protein N†
MBA	7	0·40	0·04	0·10	1·50	0·05	0·13
Henle	6	<0·01	0·12	0·10	0·05	0·22	0·15
NIH	7	<0·01	0·08	0·10	0·06	0·15	0·15

* Mgm. of phenolphthalein released by a deoxycholate lysate containing 2×10^6 cells. Incubation was at 37° C. for 2 hr. (ref. 5).
† Total nitrogen in deoxycholate lysates of two million cells. Determined by micro-Kjeldahl.
Within each experiment the cultures grown with and without prednisolone were replicate. Cells grown in medium 199 with 10 per cent human serum.
Cells were free of contamination with pleuropneumonia-like organisms and no latent viruses could be demonstrated.

Fig. 1*a* shows the results of a representative experiment with HeLa MBA, which possesses constitutive alkaline phosphatase. Alkaline phosphatase activity is expressed on the basis of two million cells (solid line and left-hand ordinate) and also on the basis of cell nitrogen (broken line and right-hand ordinate). The cells grown in medium containing prednisolone 0·5 γ/ml. have marked elevation of alkaline phosphatase activity when compared to a replicate culture grown in the absence of the hormone. Fig. 1*b* shows an experiment with HeLa NIH, a cell line with no detectable alkaline phosphatase when grown in the absence of prednisolone. In fact, alkaline phosphatase activity of lysates prepared from six times the usual concentration of cells was below the sensitivity of our method[5] (0·01 mgm. of phenolphthalein released in 2 hr. at 37° C.). When grown in medium containing prednisolone alkaline phosphatase activity is easily detected in Hela NIH.

Unlike bacterial alkaline phosphatase[2] the mammalian cell enzyme is independent of the phosphate ion concentration in the culture medium. Reduction of the phosphate medium to 0·04 m*M* does not enhance the alkaline phosphatase content in cell lines that contain the enzyme nor does it induce alkaline phosphatase in the prednisolone inducible 'negative' HeLa cells. Increase of phosphate ion concentration of the medium to 5·0 m*M* does not repress prednisolone induction of alkaline phosphatase nor does it alter the enzyme activity of cells with constitutive alkaline phosphatase. Under conditions of de-adaptation, the alkaline phosphatase activity of prednisolone-induced HeLa cells is diluted by cell multiplication.

Alkaline phosphatase may be induced also in certain cultured cell lines by high concentrations of organic monophosphates (greater than 200 γ/ml.[6]).

In summary, a hydrocortisone analogue, prednisolone, can induce alkaline phosphatase activity in certain epithelial cell lines in culture. Acid phosphatase is not significantly altered. Induction is independent of phosphate ion concentration. Under

conditions of de-adaptation the induced enzyme appears stable and is diluted by cell multiplication.

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Intracellular Free Amino-Acids of Certain Dermatophytes

THE identification and classification of the dermatophytes is dependent on macroscopic and microscopic morphological characteristics developed during growth on standard media. The formulation of biochemical tests to assist in identification would be of considerable value. The work of Mattick *et al.*[1], which showed that extracting cells of various species of *Lactobacilli* with 10 per cent acetic acid removed a mixture of amino-acids and peptides from the cells which was characteristic for each species and constant for strains within a species, suggested the application of a similar technique for the identification of dermatophyte species.

This communication records the findings for representative strains of *Trichophyton*, *Epidermophyton* and *Microsporum* species. The results show the presence in such extracts of a pattern of free amino-acids which is very similar for all organisms examined and the absence of any distinctive peptide components. It was the latter that Mattick *et al.* found of greatest taxonomic value in the *Lactobacilli*. Thus the results appear to show the pattern of cytoplasmic amino-acids in these fungi, which is borne out by the fact that other extractants, for example, 75 per cent ethanol, dimethylformamide and boiling water, known to extract the cytoplasmic contents from bacteria and fungi[2–5], have given extracts containing the same amino-acids.

It is well recognized that the patterns of the free amino-acids present in the cytoplasm of closely related micro-organisms show considerable similarity. Thus the technique is not of value in identification of the organisms; but the results are recorded as affording an interesting comparison with similar findings in *Aspergillus oryzae*[6], *Aspergillus flavus*[7], *Penicillium chrysogenum*[8] and *Neurospora crassa*[9], and as a preliminary to a more detailed examination of the amino-acid metabolism of these fungi.

The organisms were grown on a synthetic medium with DL-glutamic acid as nitrogen source. Strains of *Microsporum canis* were grown for 8–10 days at room temperature, whereas those of *Trichophyton rubrum*, *Trichophyton mentagrophytes*, *Trichophyton verrucosum* var. *discoides* and *Epidermophyton floccosum* were grown for 11–14 days at 30° C. The mycelium was collected on a sintered glass funnel and washed three times with a large volume of distilled water. The last washing was concentrated and examined by paper chromatography to ensure that carry-over of glutamic acid from the medium was minimal. The mycelium was dried so far as possible by suction, weighed and then extracted by immersion in 10 per cent (v/v) acetic acid (5 ml./gm. mycelium) for 4 hr. at room temperature. The extracts were examined for amino-acids by two-dimensional paper chromatography based on the method of Levy and Chung[10]. Whatman No. 4 chromatography paper (22 × 22 in.) was irrigated in one direction by the organic phase of butanol–acetic acid–water (4 : 1 : 5 by volume), then dried and, except for the strip containing the partially separated amino-acids, sprayed with a borate buffer of *p*H 8·3 (prepared from 300 ml. of 0·1 *M* boric acid and 60 ml. of 0·1 *N* sodium hydroxide) and again dried. The solvent system for the second dimension was prepared by mixing 30 gm. of *m*-cresol, 15 gm. phenol and 7·5 ml. of the borate buffer. The amino-acids were detected by spraying the dried chromatograms with the modified ninhydrin spray of Mattick *et al.*, drying at 40° C. for about 15 min. and then heating at 105° C. for 5 min. Hydrolysis of extracts was effected by heating with 6 *N* hydrochloric acid for 18 hr. at 120° C.

The principal amino-acids found and the frequency of their occurrence in the extracts are given in Table 1. In addition to the amino-acids shown the following were occasionally detected as faint spots on the chromatograms: cystine, lysine, asparagine, valine/methionine, glycine, leucine/*iso*leucine and threonine.

Table 1. INTRACELLULAR FREE AMINO-ACIDS OF DERMATOPHYTES (Figures refer to the number of times each amino-acid occurred)

	E. floccosum	*M. canis*	*T. rubrum*	*T. mentagrophytes*	*T. verrucosum* var. *discoides*
No. of strains examined	7	6	6	1	1
Glutamic acid	7	6	6	1	1
Glutamine	7	6	6	1	1
Aspartic acid	7	6	6	—	1
Alanine	7	4	6	1	1
Serine	4	6	6	—	1
Proline	5	6	5	—	1

Growth medium: 130 mgm. DL-glutamic acid, 36 mgm. potassium dihydrogen phosphate, 20 mgm. dipotassium hydrogen phosphate, 200 mgm. D-glucose, 20 mgm. crystalline magnesium sulphate, 140 μgm. crystalline zinc sulphate, 100 μgm. crystalline calcium chloride, 1 mgm. thiamine hydrochloride, 1 mgm. i-inositol and 100 μgm. biotin dissolved in 20 ml. glass-distilled water and brought to *p*H 6·8. The inoculum was 1·0 ml. of a homogenate of mycelium grown on Sabouraud's broth.

Hydrolysis eliminated the glutamine spot and led to the intensification of a number of spots by the hydrolysis of peptides which did not move in the solvent systems used; however, no amino-acids were found on hydrolysis which were not also present in the free state in the original extract.

These results show a similarity to those found in the other fungi cited here in that the major components of the intracellular free amino-acids are aspartic and glutamic acids, glutamine, alanine, serine and proline (except in *N. crassa*). A major difference appears to be that the basic amino-acids are absent or only present in minor amounts in the dermatophytes, whereas one or more of them are present as major components in the other fungi listed. Glycine was also present in *A. flavus*, *A. oryzae* and *P. chrysogenum* but was only seen occasionally in the dermatophyte extracts.

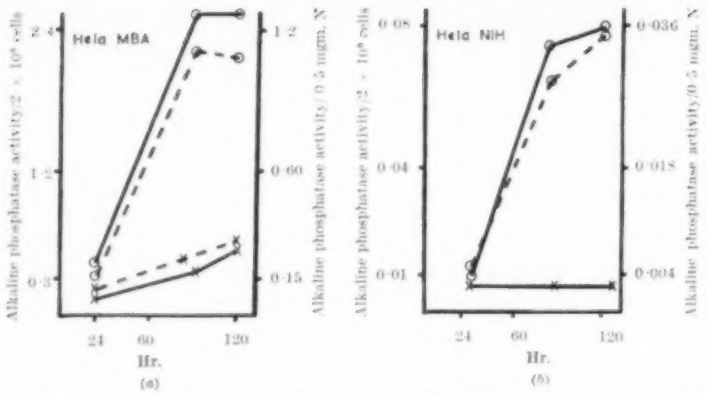

Fig. 1. Alkaline phosphatase activity of cultures grown with and without prednisolone 0·5 γ/ml.: (a), HeLa MBA, an example of a strain with 'constitutive' activity rising about 8-fold with prednisolone induction; (b), HeLa NIH, an example of a strain without detectable 'constitutive' alkaline phosphatase which develops activity by prednisolone induction. ×, without prednisolone; ○, with prednisolone. Solid line, alkaline phosphatase activity per 2 million cells; broken line, alkaline phosphatase activity per 0·5 mgm. nitrogen

Alkaline phosphatase synthesis is known to be of the inducible type in micro-organisms[2], in explants of avian and mammalian embryonic tissue[3], and in human leucocytes *in vivo*[4]. It is of particular interest that adrenal glucocorticoids induce alkaline phosphatase activity in embryonic intestinal epithelium of chicks and mice earlier than it normally appears during development.

Two HeLa lines (Henle and NIH) contain trace or no detectable alkaline phosphatase unless grown in medium containing prednisolone (Δ′ hydrocortisone) 0·5 γ/ml. In the presence of prednisolone these otherwise 'negative' lines developed as much as one-fourth the alkaline phosphatase activity usual in the other four lines. Either prednisolone hemisuccinate or prednisolone phosphate was equally effective as inducer. Most but not all epithelial cell lines with high constitutive alkaline phosphatase show an increase in enzyme when cultivated in medium with added prednisolone. We are preparing a report on the effects of prednisolone on different cell lines.

In addition to inducing alkaline phosphatase, prednisolone has a number of other effects on human epithelial cell lines. It reduces cell multiplication by about 40 per cent; it causes an increase in epithelial cell cytoplasm with almost a doubling of cell volume and a 30–50 per cent increase in cell protein. In epithelial cells grown in the presence of prednisolone, acid phosphatase activity remains constant per unit of cell nitrogen. On the other hand, alkaline phosphatase activity of inducible lines increases markedly.

Table 2 presents the result of experiments on three HeLa lines. One of these, MBA, has constitutive alkaline phosphatase and the two others, Henle and NIH, have trace or no detectable activity unless grown in medium with added prednisolone. Within each experiment all cultures were replicate and were handled similarly except for the addition of prednisolone 0·5 γ/ml. to the experimental cultures. As shown in Table 2, alkaline phosphatase activity is increased in cultures grown in medium with prednisolone whereas acid phosphatase is not significantly altered when expressed on the basis of cell nitrogen.

Table 2. Increase in Alkaline Phosphatase Activity of Cells grown with Prednisolone added

HeLa cell lines	No. of experiments	Cells (2×10^6) grown without prednisolone			Cells (2×10^6) grown with prednisolone		
		Alkaline phosphatase*	Acid phosphatase*	Protein N†	Alkaline phosphatase*	Acid phosphatase*	Protein N†
MBA	7	0·40	0·04	0·10	1·50	0·05	0·13
Henle	6	<0·01	0·12	0·10	0·05	0·22	0·15
NIH	7	<0·01	0·08	0·10	0·06	0·15	0·15

* Mgm. of phenolphthalein released by a deoxycholate lysate containing 2×10^6 cells. Incubation was at 37° C. for 2 hr. (ref. 5).
† Total nitrogen in deoxycholate lysates of two million cells. Determined by micro-Kjeldahl.
Within each experiment the cultures grown with and without prednisolone were replicate. Cells grown in medium 199 with 10 per cent human serum.
Cells were free of contamination with pleuropneumonia-like organisms and no latent viruses could be demonstrated.

Fig. 1*a* shows the results of a representative experiment with HeLa MBA, which possesses constitutive alkaline phosphatase. Alkaline phosphatase activity is expressed on the basis of two million cells (solid line and left-hand ordinate) and also on the basis of cell nitrogen (broken line and right-hand ordinate). The cells grown in medium containing prednisolone 0·5 γ/ml. have marked elevation of alkaline phosphatase activity when compared to a replicate culture grown in the absence of the hormone. Fig. 1*b* shows an experiment with HeLa NIH, a cell line with no detectable alkaline phosphatase when grown in the absence of prednisolone. In fact, alkaline phosphatase activity of lysates prepared from six times the usual concentration of cells was below the sensitivity of our method[5] (0·01 mgm. of phenolphthalein released in 2 hr. at 37° C.). When grown in medium containing prednisolone alkaline phosphatase activity is easily detected in Hela NIH.

Unlike bacterial alkaline phosphatase[2] the mammalian cell enzyme is independent of the phosphate ion concentration in the culture medium. Reduction of the phosphate medium to 0·04 m*M* does not enhance the alkaline phosphatase content in cell lines that contain the enzyme nor does it induce alkaline phosphatase in the prednisolone inducible 'negative' HeLa cells. Increase of phosphate ion concentration of the medium to 5·0 m*M* does not repress prednisolone induction of alkaline phosphatase nor does it alter the enzyme activity of cells with constitutive alkaline phosphatase. Under conditions of de-adaptation, the alkaline phosphatase activity of prednisolone-induced HeLa cells is diluted by cell multiplication.

Alkaline phosphatase may be induced also in certain cultured cell lines by high concentrations of organic monophosphates (greater than 200 γ/ml.[6]).

In summary, a hydrocortisone analogue, prednisolone, can induce alkaline phosphatase activity in certain epithelial cell lines in culture. Acid phosphatase is not significantly altered. Induction is independent of phosphate ion concentration. Under

conditions of de-adaptation the induced enzyme appears stable and is diluted by cell multiplication.

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Intracellular Free Amino-Acids of Certain Dermatophytes

THE identification and classification of the dermatophytes is dependent on macroscopic and microscopic morphological characteristics developed during growth on standard media. The formulation of biochemical tests to assist in identification would be of considerable value. The work of Mattick *et al.*[1], which showed that extracting cells of various species of *Lactobacilli* with 10 per cent acetic acid removed a mixture of amino-acids and peptides from the cells which was characteristic for each species and constant for strains within a species, suggested the application of a similar technique for the identification of dermatophyte species.

This communication records the findings for representative strains of *Trichophyton*, *Epidermophyton* and *Microsporum* species. The results show the presence in such extracts of a pattern of free amino-acids which is very similar for all organisms examined and the absence of any distinctive peptide components. It was the latter that Mattick *et al.* found of greatest taxonomic value in the *Lactobacilli*. Thus the results appear to show the pattern of cytoplasmic amino-acids in these fungi, which is borne out by the fact that other extractants, for example, 75 per cent ethanol, dimethylformamide and boiling water, known to extract the cytoplasmic contents from bacteria and fungi[2–5], have given extracts containing the same amino-acids.

It is well recognized that the patterns of the free amino-acids present in the cytoplasm of closely related micro-organisms show considerable similarity. Thus the technique is not of value in identification of the organisms; but the results are recorded as affording an interesting comparison with similar findings in *Aspergillus oryzae*[6], *Aspergillus flavus*[7], *Penicillium chrysogenum*[8] and *Neurospora crassa*[9], and as a preliminary to a more detailed examination of the amino-acid metabolism of these fungi.

The organisms were grown on a synthetic medium with DL-glutamic acid as nitrogen source. Strains of *Microsporum canis* were grown for 8–10 days at room temperature, whereas those of *Trichophyton rubrum*, *Trichophyton mentagrophytes*, *Trichophyton verrucosum* var. *discoides* and *Epidermophyton floccosum* were grown for 11–14 days at 30° C. The mycelium was collected on a sintered glass funnel and washed three times with a large volume of distilled water. The last washing was concentrated and examined by paper chromatography to ensure that carry-over of glutamic acid from the medium was minimal. The mycelium was dried so far as possible by suction, weighed and then extracted by immersion in 10 per cent (v/v) acetic acid (5 ml./gm. mycelium) for 4 hr. at room temperature. The extracts were examined for amino-acids by two-dimensional paper chromatography based on the method of Levy and Chung[10]. Whatman No. 4 chromatography paper (22 × 22 in.) was irrigated in one direction by the organic phase of butanol–acetic acid–water (4 : 1 : 5 by volume), then dried and, except for the strip containing the partially separated amino-acids, sprayed with a borate buffer of *p*H 8·3 (prepared from 300 ml. of 0·1 *M* boric acid and 60 ml. of 0·1 *N* sodium hydroxide) and again dried. The solvent system for the second dimension was prepared by mixing 30 gm. of *m*-cresol, 15 gm. phenol and 7·5 ml. of the borate buffer. The amino-acids were detected by spraying the dried chromatograms with the modified ninhydrin spray of Mattick *et al.*, drying at 40° C. for about 15 min. and then heating at 105° C. for 5 min. Hydrolysis of extracts was effected by heating with 6 *N* hydrochloric acid for 18 hr. at 120° C.

The principal amino-acids found and the frequency of their occurrence in the extracts are given in Table 1. In addition to the amino-acids shown the following were occasionally detected as faint spots on the chromatograms: cystine, lysine, asparagine, valine/methionine, glycine, leucine/*iso*leucine and threonine.

Table 1. INTRACELLULAR FREE AMINO-ACIDS OF DERMATOPHYTES (Figures refer to the number of times each amino-acid occurred)

	E. floccosum	*M. canis*	*T. rubrum*	*T. mentagrophytes*	*T. verrucosum* var. *discoides*
No. of strains examined	7	6	6	1	1
Glutamic acid	7	6	6	1	1
Glutamine	7	6	6	1	1
Aspartic acid	7	6	6	—	1
Alanine	7	4	6	1	1
Serine	4	6	6	—	1
Proline	5	6	5	—	1

Growth medium: 130 mgm. DL-glutamic acid, 36 mgm. potassium dihydrogen phosphate, 20 mgm. dipotassium hydrogen phosphate, 200 mgm. D-glucose, 20 mgm. crystalline magnesium sulphate, 140 μgm. crystalline zinc sulphate, 100 μgm. crystalline calcium chloride, 1 mgm. thiamine hydrochloride, 1 mgm. *i*-inositol and 100 μgm. biotin dissolved in 20 ml. glass-distilled water and brought to *p*H 6·8. The inoculum was 1·0 ml. of a homogenate of mycelium grown on Sabouraud's broth.

Hydrolysis eliminated the glutamine spot and led to the intensification of a number of spots by the hydrolysis of peptides which did not move in the solvent systems used; however, no amino-acids were found on hydrolysis which were not also present in the free state in the original extract.

These results show a similarity to those found in the other fungi cited here in that the major components of the intracellular free amino-acids are aspartic and glutamic acids, glutamine, alanine, serine and proline (except in *N. crassa*). A major difference appears to be that the basic amino-acids are absent or only present in minor amounts in the dermatophytes, whereas one or more of them are present as major components in the other fungi listed. Glycine was also present in *A. flavus*, *A. oryzae* and *P. chrysogenum* but was only seen occasionally in the dermatophyte extracts.

We wish to thank Dr. Jaqueline Walker and Dr. C. J. La Touche for strains of the organisms used in this work.

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A New Fatty Acid from Royal Jelly

It has been shown by Butler, Callow and Johnston[1] that queen honey-bees (*Apis mellifera*) secrete material which affects bees in two ways, inhibiting the development of ovaries in workers and influencing their behaviour by inhibiting queen rearing. Callow and Johnston[2] have determined that the active principle in the material is 9-oxodec-2-enoic acid. It is referred to as 'queen substance'.

The close structural relationship between this 'queen substance' and 'royal jelly acid', 10-hydroxydec-2-enoic, found abundantly in royal jelly, would lead one to assume that the latter is a precursor of the former. Moreover, it would seem reasonable to predict that 9-hydroxydec-2-enoic acid might be an intermediate, and possibly occur in small amounts in royal jelly.

We observed that the carboxylic acid mixture, isolated from royal jelly by the procedure described by Brown and Freure[3], gives a weak iodoform reaction but no test for the carbonyl function with 2,4-dinitrophenylhydrazine. Oxidation of this acid mixture with aqueous chromic acid gave a product which, on treatment with aqueous 2,4-dinitrophenylhydrazine reagent, yielded a small amount of a 2,4-dinitrophenylhydrazone. This derivative has an infra-red absorption spectrum identical with that of the 2,4-dinitrophenylhydrazone of 9-oxodec-2-enoic acid.

Thus it appears that 9-hydroxydec-2-enoic acid is present in royal jelly in minute amounts. A more detailed account of the investigation will be published later.

Authentic samples of 9-oxodec-2-enoic acid and its 2,4-dinitrophenylhydrazone were supplied by Dr. R. K. Callow and Miss Norah C. Johnston, for which we are grateful.

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PHYSIOLOGY

Oscillatory Flow in a Fluid-filled Elastic System

There is a pronounced tendency for a fluid-filled elastic tube to oscillate when the fluid is caused to flow by a small head of pressure. This may be demonstrated with a model (Fig. 1) which stems from a new theory of the action of the heart, published by me[1].

Water flows from the tap into a reservoir where a constant level is maintained, then down a rigid tube connected at the lower end to a rubber tube lying horizontally on a small platform. The distal end of the rubber tube is connected to a short length of rigid tubing, through the other end of which fluid is allowed to escape freely into the sink. Provision is made to vary the height of the reservoir and of the outlet.

Arranged parallel to the platform is a metal bar on which three springs are mounted which can be moved at will. These are of mild steel, twisted around the bar and secured at one end by a clamp. The other end of each is drawn out into a straight extension that presses against the rubber tube, with a force equivalent to a weight of 50 gm. approximately, the tension being adjusted by twisting the spiral part of the spring with the clamp.

Latex tubing is employed (0·7 cm. in diameter) with a volume pressure curve almost linear up to a pressure of 150 cm. of water. A suitable length, to start with, is 97 cm., the reservoir being set 1 m. above, and the outflow 4 cm. below, the level of the platform.

The position and pressure of the springs are adjusted until maximum oscillation occurs, when each is found to be at a critical distance from the distal end of the tube. A water hammer now develops, associated with momentary interruption and even regurgitation of flow. A sharp sound is heard at each pulse,

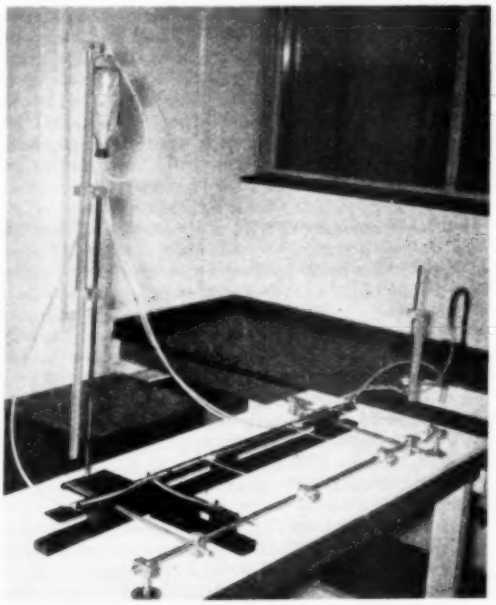

Fig. 1. The oscillator

audible at a distance of half a metre when the springs are correctly arranged. To facilitate the adjustment, the sound is detected with the aid of a microphone which is seen to the right of the model, at the back. Sounds are generated at the site of each spring but the loudest occur at the site of the distal end.

Oscillation is explained as follows: Viscous drag of the fluid in contact with the elastic wall produces waves which are reflected from the distal end of the tube: flow being slowed by the distal spring, stationary waves develop upstream where the flow velocity corresponds to the wave-length.

The stationary waves are of two types, long of some 75 cm. and short of about 1·5 cm., corresponding to gravity and capillary waves respectively. Current and pressure become 90 deg. out of phase in a manner similar to that of the current and voltage when stationary waves arise in an electrical transmission line, as a result of reflexion from a short-circuited end. The two proximal springs locate adjacent antinodes of the system of longer waves, giving the half wave-length. The corresponding quarter wave-length is given by the distance between the middle and distal springs; but, owing to the development of short waves at the distal end, the distal spring determines the site of a pseudo-stationary node about 1·5 cm. from the end of the tube.

When stationary wave motion is established, either of the two proximal springs, by altering the cross-sectional area of the tube, produces velocity modulation of the stream. The distal spring affects density modulation and, resonating, gains energy from the stream. Part of the energy is fed back as a wave which drives the proximal spring.

By altering the height of the reservoir and that of the outlet, differing frequencies of oscillation are obtained, as also by regulation of the pressure of the individual springs. In the case of the distal spring the closer the point of application to the end of the tube, the higher the frequency and conversely. Harmonics occur, a variety of modes of oscillation and occasionally a mode jump.

A 'T'-piece is introduced into the proximal segment of the elastic tube at the site of a node, the side branch communicating with a further piece of rubber tubing 20 cm. in length, the other end of which is closed with a piston. Adjustment of the position of the piston enables the device to be used as a quarter-wave matching stub, to suppress stationary waves at the inflow which otherwise interfere with the motion of the proximal spring.

The model, which will oscillate when filled with blood instead of water, demonstrates that stationary waves, in the centimetre range, readily arise in fluid-filled elastic tubes at physiological pressure. That oscillation is obtained from a stream maintained in flow by a pressure, initially constant, raises the question as to whether the peripheral pulse is developed from the static pressure of the blood in the great vessels and not from the heart wave.

Further work on this is proceeding.

Thanks are due to the Postgraduate Medical School of London, in particular to Prof. Ian Aird and Mr. W. J. Dempster, for research facilities in the Experimental Surgical Unit, also to Dr. D. G. Melrose for loan of equipment.

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Response of Thymus to Increase of Intake of Sodium Chloride

It is a well-known fact that the metabolism of the body fluids and electrolytes is closely connected with all metabolic processes in tissues. I have examined the significance of the changes in sodium balance for the activity of the lymphatic tissue of the thymus.

Adrenalectomized rats were used (Wistar, males, average weight of each group 190–222 gm.): (1) treated with deoxycorticosterone acetate (DCA), 2 mgm. intramuscularly per rat daily, and supplied with tap water; (2) treated with the same doses of DCA and supplied with isotonic saline solution. Treatment with DCA started immediately after adrenalectomy and later after 24 and 48 hr. respectively. 72 hr. after adrenalectomy the rats were killed by decapitation. The thymus was weighed and the lymphocytes of thymus were counted. At the same time a part of muscle (m. quadriceps femoris) was removed for electrolyte analysis. The specimens of the muscle were dried, defatted, and the potassium and sodium content was determined by flame photometry and expressed in millequivalents of ions per 100 gm. of fat-free dried material.

The analysis of the electrolyte concentration of the muscle has shown that the animals of the group treated with DCA and supplied with tap water maintain a relative balance in electrolytic proportions (intact control rats: potassium, 46·0 m.equiv./100 gm.; sodium, 10·5 m.equiv./100 gm.). Animals treated with DCA and saline have shown an increased retention of sodium which is demonstrated by a lower concentration of potassium and a corresponding increase of sodium in muscle. It is a well-known fact that sodium chloride stimulates the excretion of potassium in animals treated with DCA (ref. 1).

Table 1 shows that the animals treated with DCA and saline have an enlarged thymus. An increase in the average weight of the thymus is conditioned by an increase in the number of cells. The mean weight of the thymus of animals treated only with DCA does not differ from the mean weight of the thymus of intact control animals of the same body-weight (n-13, mean thymus weight: 180 mgm.).

Table 1

Treatment	Mean body-weight (gm.)	Mean thymus weight (mgm.)*	No. of cells 10^6*	Muscle electrolytes (m.equiv./100 gm.) Na	K	Na/K*
DCA	192 (10)†	177	576	12·1	44·9	0·26
DCA + NaCl	199 (21)	241	872	13·3	41·0	0·31

* Statistical significant differences between both groups ($P < 0·01$).
† In parentheses, number of rats used.

The experiments have shown that the thymus of adrenalectomized animals reacts to stimuli produced by an imbalance in the electrolytes of the internal environment (increase of sodium intake) by intensified activity. The mechanism of this action is not clear. We may assume both direct and indirect influence. It is known that the maintenance of ion concentration gradients requires metabolic energy. The hyperfunction of the thymus tissue may perhaps be an expression of increased metabolic efforts to maintain the homeostasis of the internal environment. My results indicate that the electrolyte metabolism has

an important role in the regulation of the growth of thymolymphatic tissue.

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Determination of Physiological Rhythms of Unrestrained Animals by Radio Telemetry

The results of 24-hr. rhythm measurements are frequently influenced by perturbations due to the presence of an observer and the measuring equipment. These perturbations can be minimized if the desired physiological data are obtained by radio telemetry[1,2]. The transmitter carried by the animal should be characterized by small size, long battery life, and sufficient range for unrestrained movements. Several transmitters with these design goals were constructed successfully and used to relay temperature and heart-rate information to a distant observer.

The transmitters contain a basic oscillator which is frequency-modulated by a voltage proportional to the phenomenon measured. For a description of the design, see ref. 3. The frequency of each temperature transmitter is controlled in part by the intrinsic dependence on temperature of the transistor in the oscillator and also by a voltage derived from a thermistor half-bridge circuit. The transmitter is built around the antenna, which is a ferrite core. The life of the 75 MAH mercury cell in this circuit exceeds 200 days. The frequency of the E.K.G. transmitter is controlled by amplified potentials derived from the heart. Additional circuitry is needed for amplification; this increases power consumption and reduces battery life to about forty days. Units with more batteries have a longer life. Both the temperature and the E.K.G. units are suitable for surgical implantation provided a non-toxic covering is used. In these experiments temperature transmitters were hermetically sealed in cases machined from nylon rod. The temperature-sensitive elements were covered with the tip from a finger of a latex surgical glove, although they could be designed to protrude into a portion of a nylon shell. Seals between the latex finger tip and the nylon case were made successfully by wrapping and tying with nylon suture. No toxic reactions were noted when a unit prepared in this manner was implanted in a dog. Ref. 3 describes the pretreatment required before implantation.

In a series of short experiments 24-hr. rhythms (circadian rhythms) of heart-rates for a dog, a cat and a rabbit were obtained. In each case the animal was trained to wear a harness on which the transmitter was mounted. The input leads to the transmitter were connected to tantalum electrodes which were implanted surgically weeks in advance. The electrodes were put in subdermally over the right scapula and on the dorsal mid-line near the first lumbar vertebra, a position favouring the detection of heart-potentials. Fourier analysis of the data was made in order that the 24-hr. periodicity could be expressed quantitatively in the form:

$$F(t) = C_0 [1 + C_1 \sin(15t + \theta_1) + C_2 \sin(30t + \theta_2) + \ldots + C_n \sin(15t + \theta_n)]$$

One may think of this Fourier series as a curve of best fit for the given frequency components. The Fourier series approximation, which is uniquely

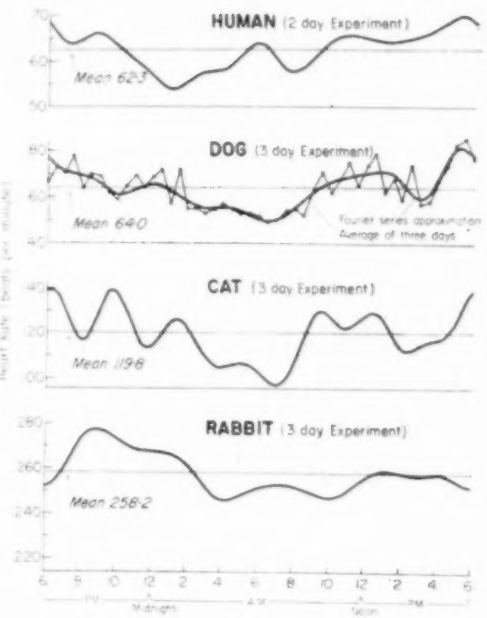

Fig. 1. 24-hr. periodicity in heart-rates of man and three laboratory animals. A Fourier series approximation was used for curve smoothing. Original data for the dog are included

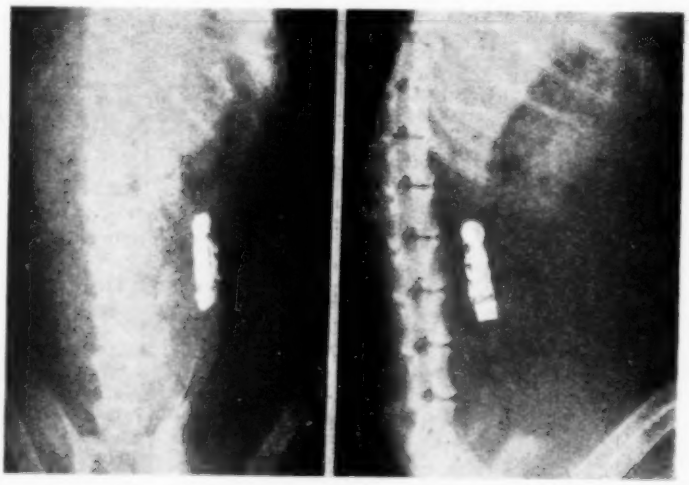

Fig. 2. Dorsal-ventral (left) and right to left lateral (right) roentgenographs showing position of the temperature transmitter in the dog

applicable to repetitive phenomena, is analogous to the nth order polynomial of best fit frequently used in statistical analysis. The 3-day average heart-rate of a dog is shown in addition to the Fourier series approximation (Fig. 1). In each analysis the average value (C_0) plus eight frequency components were used. Note that the centre of the period of lowest heart-rates for man occurs at 3 a.m., and this time progresses to 5 a.m. for the dog, 6 a.m. for the cat, and 8 a.m. for the rabbit. These experiments were conducted when the human subject and the experimental animals were isolated in an insulated, quiet chamber with a 12-hr. light cycle (6 a.m.–6 p.m.). Data were recorded outside the chamber from signals picked up by an antenna.

Simultaneous body temperatures and heart-rates of the dog were also recorded to study the interdependence of these variables. The technique for measuring heart-rates in this experiment is as described, but with the animal wearing a harness. A temperature transmitter was put in retroperitoneally immediately caudal to the right kidney (Fig. 2). A 12-day recovery period was allowed before the experiment was begun. The resulting data (Fig. 3) indicate a close correlation between the two variables.

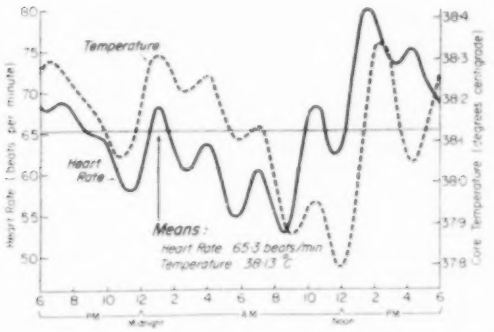

Fig. 3. Fourier series approximation of 24-hr. periodicity in core temperatures and heart-rates of a dog. The original data were obtained during a 24-hr. experiment

The data presented here support previous concepts of the day–night heart-rate characteristics of human beings, dogs, cats and rabbits. In addition, a very close correlation has been shown to exist between heart-rate and core temperature in the dog. These pilot experiments, which tested the radio telemetry technique for measuring temperature and heart-rate over extended periods of time, justify additional experiments of longer duration involving more animals.

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Effect of Dexamethasone on the Phagocytic Activity of the Reticulo-Endothelial System

IT has been reported previously[1] that cortisone, prednisone and prednisolone are strong depressants of the reticulo-endothelial system. The mechanism by which cortisone lowers the body defences has been shown by Nicol *et al.*[2] to be due to depression of the phagocytic activity of the reticulo-endothelial system, the total and differential white cell counts in the blood, and the gamma globulin-level in the serum. It has also been shown that after cortisone treatment is stopped, the depressant action of the cortisone can be reversed[2] and converted into one of moderate stimulation by diethylstilboestrol. However, if cortisone and diethylstilboestrol are administered separately, but at the same time, the depressant action of cortisone is prevented and considerable stimulation of phagocytic activity occurs.

The present research was carried out to ascertain the effect of dexamethasone phosphate on the phagocytic activity of the reticulo-endothelial system and compare it with the effects of cortisone acetate, prednisone and prednisolone previously reported[1].

The present experiments were made on 20 male white mice (*T.O.* Swiss strain) of 20–25 gm. body-weight. Ten of the animals each received 0·5 mgm. dexamethasone phosphate in aqueous solution subcutaneously, once daily, for 6 days. On the eighth day after the commencement of the treatment, the phagocytic activity was measured by the rate of disappearance of a known amount of specially prepared carbon from the circulating blood[4]; the procedure which we used is that described in previous communications[1,3] and the total body phagocytic activity or phagocytic index is denoted by the symbol K. Ten control animals received no treatment and in these the phagocytic activity was also measured by the carbon method.

After the assessment of the phagocytic activity, blood counts were made in all the animals, which were then killed and the weights of the liver and spleen determined.

The results show that in the mouse the phagocytic index in the control animals ($K = 20$) is depressed by dexamethasone ($K = 9$), compared with cortisone ($K = 7$), prednisone ($K = 8$) and prednisolone ($K = 8$)[1]. In the animals treated with dexamethasone, no change was found in the weights of the liver or spleen; and in the blood, the total red cell count was normal, the circulating lymphocytes were reduced from a control-level of 5,000 to 1,900 per cu. mm., the polymorphs increased from 1,400 to 2,500 per cu. mm. and the monocytes remained unaltered in number. Reduction in the number of lymphocytes was also found in guinea pigs treated with cortisone[5], but during the first week of treatment the polymorphs became reduced in number, then increased during the second week.

The therapeutic dose of dexamethasone is stated to be 5–7 times less than that of prednisone or prednisolone; and clinically, it is 28 times more potent than hydrocortisone and about 35 times more potent than cortisone.

The present results show that dexamethasone phosphate, like cortisone acetate, prednisone and prednisolone, is a strong depressant of phagocytic activity, but, although it is much more potent clinically than cortisone, its depressant effect on the reticulo-

endothelial system is of no greater magnitude than that of the other corticosteroids at present in use.

In these researches we gratefully acknowledge a gift of dexamethasone from Messrs. Merck, Sharp and Dohme and financial assistance from the Medical Research Council.

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Effect of Hæmophagin on the Phagocytic Activity of the Reticulo-Endothelial System

Hæmophagin is produced at the Austrian Institute for Hæmoderivatives, Vienna, by a special catalytic method from the blood of normal donors. It is stated to increase antibody formation against various bacterial antigens and also to cause increased phagocytosis; and it is given intramuscularly or intravenously when there is danger of infection after operation or injury.

It is generally acknowledged that the reticulo-endothelial system is an important defence of the body against infection, and extensive researches on the functions of the reticulo-endothelial system have recently been reported. We have previously shown[1–3] that the active œstrogens are strong stimulants of the reticulo-endothelial phagocytes; and unpublished results in our laboratory also show that when the reticulo-endothelial system of the guinea pig is stimulated the serum gamma-globulin is raised to about twice the normal level, and, in addition, both mice and guinea pigs are protected against virulent infections. It therefore seems rational that when antibacterial substances are being used to combat infection the reticulo-endothelial system should at the same time be stimulated to raise the body defence. The œstrogens may be used for this purpose but most of them have undesirable side-effects. In view of this, extensive research is being conducted to find, if possible, a strong reticulo-endothelial stimulant without œstrogenic effects. In these circumstances, we have been interested in testing the claimed action of hæmophagin by our experimental methods.

Fifty male white mice (*T.O.* Swiss strain) of 20–25 gm. body-weight were used for this investigation. Ten of the animals each received 1/40 of the human dose of hæmophagin once daily intramuscularly for 6 days and a second group of ten received half the dose for the same period. On the eighth day the phagocytic activity was measured in each animal by the rate of disappearance of a known amount of specially prepared carbon from the circulating blood[4], the procedure used being that described in previous communications[2,3] and the total body phagocytic activity or phagocytic index being denoted by the symbol *K*. Thirty of the animals were used as controls. Ten control animals received no treatment; ten received diethylstilbœstrol 0·1 mgm. once daily subcutaneously for 6 days; and ten received tri-*p*-anisylchloroethylene 1·0 mgm. once daily orally for 6 days. The phagocytic activity was also measured in the control groups by the carbon method, which was carried out on the eighth day in those treated with diethylstilbœstrol and tri-*p*-anisylchloroethylene. After the assessment of phagocytic activity blood counts were made in all the animals; they were then killed and the weights of the liver and spleen determined.

The results were as follows: In the untreated control animals the total phagocytic index (*K* value) was 16 ± 2, while in the control groups given diethylstilbœstrol and tri-*p*-anisylchloroethylene the *K* values were 75 and 83 respectively. In the animals which received a daily dose of 1/40 of the human dose of hæmophagin the *K* value was 19 ± 2 and in those which received a daily dose of 1/80 of the human dose the *K* value was 13 ± 1.

In the blood of the hæmophagin-treated animals no change was found in the total red cell count. When the dose of hæmophagin was 1/40 of the human dose, the total white cell count increased from a control level of 8,000 to 11,000 per cu.mm., the increase being due to increase in the number of circulating lymphocytes from 6,000 to 9,000 per cu.mm.; when the dose of hæmophagin was 1/80 of the human dose the total white cell count remained within normal limits.

The above results suggest that hæmophagin has little or no effect on the phagocytic activity of the reticulo-endothelial system of mice and that its action may be related to its influence on the white cells of the blood.

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Incorporation of Palmitic-1-^{14}C Acid into Blood Cells

It has been shown that Ehrlich mouse ascites tumour cells *in vitro* readily absorb palmitic acid and use it as an energy source and for synthesis of other lipids[1]. Although this has not been demonstrated for blood cells, it has been reported by several investigators that these cells are able to synthesize lipids from acetate[2–5].

The present investigation concerns the incorporation of palmitic acid-1-^{14}C into the lipids of blood cells during incubation.

To 150 ml. of fresh human blood was added 37·5 ml. of A.C.D. solution (1·32 per cent sodium citrate, 0·48 per cent hydrous citric acid, 1·47 per cent dextrose). After centrifugation at 900*g* for 15 min., 50 ml. of the plasma was removed and shaken for 5 min. with 9·5 ml. of potassium palmitate-1-^{14}C solution. (This solution contained 3 mgm. of palmitic

acid-1-^{14}C dissolved in 9·5 ml. of 0·01 *M* potassium hydroxide with a total radioactivity of 35,112 c.p.s.) The plasma-palmitate mixture was added to the blood cells and remainder of the plasma. Fifteen-ml. samples of this suspension were then incubated with slight shaking at 37° C. in an atmosphere of 5 per cent carbon dioxide–air and in the presence of 1,000 units per sample of both penicillin and streptomycin. Some of the incubations were carried out in the presence of 72γ of œstrone or 200γ of ethylenediamine tetraacetic acid (added as the sodium salt) per ml. of suspension. After 8 hr. the cells were separated and freed from the plasma and the lipids of both were extracted by the method of Delsal[6].

Total radioactivity was measured in a flow counter (Nuclear Instruments and Chemical Corporation *D*-47 Micromil Flow Counter). Total lipids were separated by silicic acid chromatography into six fractions (cholesterol esters, triglycerides, cholesterol, diglycerides, monoglycerides and phospholipids) using a modification (1, 5, 10 and 25 per cent ether in petroleum ether, ether and methanol) of the method described previously[1–7].

The first 3 fractions were purified by passage through a short alumina column to remove free fatty acids[7] and the radioactivity of each fraction was measured by the direct plating technique of Entenman *et al.*[8].

Under the conditions of the present experiment, at least 10 per cent of the total radioactivity of added palmitic acid was recovered in the blood cells. The radioactivity was found largely in the triglyceride, cholesterol and phospholipid fractions.

In general the glyceride fractions had the highest specific activity although the greatest percentage (more than one-half) of the total activity was in the phospholipid fraction. No significant amount of radioactivity was found in the cholesterol ester fractions. Some evidence was obtained indicating that in the presence of ethylenediamine tetraacetic acid and œstrone the distribution of the radioactivity among the different lipids was altered.

These results will be discussed in greater detail in a subsequent communication.

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Effect of Castration on Experimental Liver Lesion in *Iguana iguana*

To gain an impression of the development of the hormones produced by the ovary in the liver of *Iguana iguana* in 30 castrated and 30 mature females a liver lesion was effected by means of the carbon tetrachloride method of Kaufmann. Afterwards the animals were observed for 70 days, the deaths occurring during this period being recorded. Just as in the rat[1,2], deaths began immediately in the mature group, most animals succumbing in the third week.

In the group of the castrated animals no losses were suffered in the first few weeks. Deaths occurred not before the fourth week with a maximum in the fifth week. In a period of 70 days, 24 of the 30 mature animals died and only 10 of the 30 castrated animals. This significant difference between the death-rates of the two groups suggests that castration is capable of exerting a protective action in the experimental liver lesion and that the hormones provided by the ovary reach development more poorly in the mature than in the castrated animals. This is also suggested by observations that in the case of an equal degree of liver lesion the castrated animals tolerate better the load of experimentally administered ovarian extract and evidently the injected animals develop more rapidly than the mature animals.

These results are in good agreement with the data obtained in the rat[1,2], and therefore have a certain general significance. Obviously, the no longer normal liver is seriously damaged by the hormones produced by the ovary, so that the mature animals perish more rapidly and in larger numbers after liver lesions. When the source of these hormones is eliminated by castration, the liver can to a considerable extent be relieved, through which the progress of the disease is prevented.

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HÆMATOLOGY

Absence of Abnormal Hæmoglobins in Colombian Tunebo Indians

An examination by paper electrophoresis has been carried out of hæmoglobin from 100 Tunebo Indians from the Santa Librada Mission located at San Luis de Chuscal (Department of Santander, Colombia). This tribe, whom historical and anthropological references consider to be a branch of the large Chibcha Indian group, consists of approximately 2,000 inhabitants spread over 22 small communities along the Rivers Suisiga, Cobaría and Cobugón, tributaries of the River Arauca, situated on the eastern slopes of the Sierra Nevada de Cocuy, between lat. 6° 15′ and 7° 10′ N., and long. 71° 50′ and 72° 20′ W. All the individuals studied were adults, apparently normal. Both sexes were proportionally represented and the blood was drawn only from subjects not closely related.

The haemoglobin solution was prepared by Drabkin's method[1] without the use of aluminium chloride. Paper electrophoresis was carried out in a tank permitting the use of two sheets of 46·5 cm. × 21·0 cm. filter paper, resting on two glass rods, on an inclined plane at 45° with the anode facing the higher end. The size of the sheets facilitated comparing the relative migration of seven different samples. This method is somewhat similar to that used by Gordon *et al.*[2] for serum proteins.

All the samples examined showed a single spot with the same mobility as haemoglobin A, indicating that no abnormal haemoglobin could be detected by this method in the Tunebo Indians.

This work, which is apparently the first of its kind ever conducted on a Colombian population, confirms previous assumptions[3] that either American Indians lack abnormal haemoglobins, or the frequency of occurrence of such haemoglobins is very low. In spite of the relatively few subjects examined, who represent but 5 per cent of the whole tribe, the results obtained seem to indicate that either the stimuli which in other continents are presumed to have led to the production of abnormal haemoglobins have not been operative in this Mongoloid branch on the American continent, or the whole Indian stock has enough 'resistance' not to undergo these mutations.

It is interesting to note, in this respect, that the ecological conditions in which these Indians live still permit a high incidence of malaria. By combining the results obtained in the present work with results found for Venezuelan Indians inhabiting malarial zones[4], it may be concluded that although the sickle-cell trait confers a certain resistance to malaria, as shown by Allison, the mutation leading to the production of haemoglobin S is apparently not produced by malaria. As a matter of fact, this phenomenon has not yet been observed in pure South American Indians.

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Bohr Effect in the Hæmoglobins of Marine Mammals

Vertebrate blood haemoglobins discharge protons on oxygenation. This is part of the Bohr effect[1]. Recent work[2,3] has shown that in haemoglobins from a variety of terrestrial mammals ranging in size from mouse to elephant the smaller the animal the greater is the sensitivity of its haemoglobin to changes in *p*H. Thus elephant haemoglobin discharges only about 1·5 protons during oxygenation while mouse haemoglobin discharges about 3·8. An approximate inverse linear relation exists between the number of protons discharged by the haemoglobin during oxygenation and the logarithm of the body-weight of the animal from which the haemoglobin comes: one additional proton discharged corresponds to a decrease in body-weight by a factor of about 300. The extrapolation of this relationship to the weights of large whales suggested that whales might possess haemoglobins with either a zero or small Bohr effect.

I have now examined the haemoglobins of the humpback whale (*Megaptera nodosa*), pilot whale (*Globicephala scommonie*), and harbour porpoise (*Phocaena phocaena*), and find that the relation between the Bohr effect and body-weight existing among terrestrial mammals does not appear, so far, to extend to marine forms.

All blood samples were treated immediately with 0·1 vol. of 0·5 per cent sodium citrate and placed on ice. The preparation of the haemoglobins was identical with that previously described[2]. The washed cells were lysed with distilled water and the haemolysate then dialysed versus glass-distilled water for 15 hr. Cellular debris was removed by high-speed centrifugation. The oxygen equilibrium was determined as previously described in 0·1 *M* potassium phosphate buffer at various *p*H values between 7·0 and 7·6 at 35° C.[2]. The haemoglobin concentrations were $1·4 \times 10^{-3}$ *M* (whale), $0·9 \times 10^{-3}$ *M* (porpoise), and $0·6 \times 10^{-3}$ *M* (pilot whale) on the basis of oxygen capacity measurement and assuming 4 molecules of oxygen per mole haemoglobin. All measurements were made within 72 hr. of the original drawing of the blood.

The results of these measurements are given in Table 1. The porpoise and pilot whale have haemoglobins with identical Bohr effects, about 0·52, expressed as $\frac{\Delta \log P_{50}}{\Delta\, pH}$, although porpoise haemoglobin has an over-all oxygen affinity 38 per cent lower than pilot whale haemoglobin. In contrast, humpback whale haemoglobin possesses a large Bohr effect, $\frac{\Delta \log P_{50}}{\Delta\, pH}$ being about 0·82. Both the Bohr effect and the oxygen affinity are almost identical with those previously found for guinea pig haemoglobin[2].

Large whales are known to be able to remain submerged for at least 1 hr.[4]. It appears that the large Bohr effect may be a homeostatic molecular adaptation facilitating diving for long periods. It would augment the physiological adaptations already known: the tolerance of high carbon dioxide concentration, the large blood volume, the high haemoglobin concentration, the high concentration of myoglobin in the muscles, and low lung volume[4,5]. A large Bohr effect would enable the blood to absorb more carbon dioxide with a smaller drop in blood *p*H than would otherwise be possible. Similarly, a large Bohr effect should facilitate the discharge of the accumulated carbon dioxide when the animal surfaces.

The lower Bohr effect in pilot whale and porpoise haemoglobins presumably reflects their predominantly surface behaviour. Although the humpback whale is also a surface feeder, it can dive for much

Table 1. All Experiments performed at 35° C. in 0·1 *M* Phosphate Buffer

Animal	*p*H	log P_{50} (in mm. mercury PO_2)	$\frac{\Delta \log P_{50}}{\Delta\, pH}$	Estimated weight (kgm.)
Porpoise	7·03	1·382	0·52	90
	7·32	1·231		
Pilot whale	7·08	1·220	0·52	680
	7·39	1·058		
Humpback whale	7·08	1·395	0·82	41,000
	7·42	1·115		

longer periods than either the porpoise or the pilot whale. Observations by Dr. Kenneth S. Norris (private communication) indicate that the average diving time of pilot whales is less than 3 min., and seldom more than 5 min. Similarly, the harbour porpoise seldom dives for more than a few minutes.

In summary, the humpback whale, known to be capable of long dives, has a haemoglobin with a large Bohr effect, while the pilot whale and harbour porpoise apparently do not dive for as long periods and have blood haemoglobins with much smaller identical Bohr effects.

Humpback whale haemoglobin was obtained from an adult male, estimated weight 41,000 kgm., within 12 hr. after the death of the animal. Pilot whale blood was obtained by syringe from the counter-current vessels of the flukes of a 12-ft. male weighing about 680 kgm. Porpoise blood was obtained by syringe immediately after catching a harpooned animal weighing about 90 kgm.

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Leptospira-agglutinating Factors in Turtle Sera

IN our epidemiological research on the carriership of pathogenic *Leptospira* among wild animals in Israel, 58 swamp turtles (*Clemmys caspica*) of various ages originating from twelve different regions of the country were investigated for the presence of agglutinins. Serum tests were carried out against 13 serotypes of *Leptospira* (*L. icterohaemorrhagiae, canicola, grippotyphosa, pomona, hebdomadis, sejroe, australis A, autumnalis Rachmat, bataviae, hyos, ballum, poi* and *mini Szwajizak*). With 11 of these strains no reaction was observed. However, all sera showed highly significant titres in the agglutination test with *L. ballum*, both the 'complete' (Castellon) strain and the 'incomplete' (*S* 102) strain. (Three sera reacted with titre 250, two with titre 500, seven with titre 1,000, fourteen with titre 2,000, fourteen with titre 4,000, twelve with titre 8,000, three with titre 16,000 and four with titre 32,000.) Besides agglutinins, lysins were also demonstrated. In fifteen sera low titres were also found for *L. hyos* (eight up to 50, five up to 100, three up to 250), the remaining sera showing no agglutination with this serotype. Negative results were obtained too with *L. icterohaemorragiae* 'incompleta' and *L. sarmini*, which have some antigenical relationship with *L. ballum*.

None of the turtle sera agglutinated four out of five saprophytic water *Leptospira* strains (*L. biflexa*, provided by Dr. C. D. Cox, Vermillion, S.D.), and *L. Sao Paulo, L. Patoc I, L. Wa-Z* and *L. Wa-Leiden*, all provided by Prof. J. W. Wolff, Amsterdam).

A fifth strain of water *Leptospira*, *L. biflexa-Gent* (from Prof. Wolff), however, was agglutinated to approximately the same titres as *L. ballum* by all *Clemmys* sera examined (one in dilution 1 : 250, five 1 : 500, four 1 : 1,000, seven 1 : 2,000, six 1 : 4,000, four 1 : 8,000, six 1 : 16,000 and two 1 : 32,000).

Leptospira could not be isolated in direct culture from the liver, spleen and kidneys of the turtles, nor from the organs of hamsters intraperitoneally injected with a mixture of drained *Clemmys* organs.

It is remarkable that without exception the sera of *Clemmys* (of very different ages and at least partly from widely removed regions of the country) showed practically the same high agglutination-level with one of the strains of water *Leptospira* (*L. biflexa-Gent*) as with *L. ballum*, although these serotypes have no antigen in common. This aroused some doubt as to whether the serum reactions of the turtles depended on the classical antigen–antibody phenomenon.

The following investigations were intended to throw more light on the active agent in the sera of turtles compared with agglutinating antibodies provoked as a result of active immunization with the serotype strains concerned.

The globulins were separated from our *Clemmys caspica* sera, by ammonium sulphate precipitation, then washed and dialysed. Quantitatively the total amount of the agglutinating factor was contained in the globulin fraction of the sera.

A culture of *L. ballum* failed to be agglutinated in the presence of *Clemmys* sera and of sera of rabbits immunized against *L. ballum*, when the antigen was washed and finally suspended and the sera were diluted in distilled water. Consecutive addition, to the negative tests, of saline to a final concentration of 0·9 per cent brought about immediate reaction up to the original agglutination-level of the sera. This result indicated the necessity of the presence of electrolyte for this reaction.

The influence of high temperature on the agglutinating agent was investigated in twelve sera of *Clemmys caspica* and three sera of rabbits immunized against *L. ballum*. The critical temperature at which the turtle and rabbit sera lost their agglutinating property was 68°–69° C.

After freezing and consecutive thawing of turtle sera, the concentration of the agglutinating factor on the bottom of the tubes was about 20-fold that of the supernatant layer.

The 'agglutinins' were totally absorbed from *Clemmys* sera by addition of an adequate amount of *Leptospira* of the ballum serotype. The 'incomplete' serotype (*S* 102) deprived turtle sera of their agglutinating factor for the 'complete' (Castellon) strain as well as for the incomplete serotype. Hence the active factor in turtle sera reacts as an agglutinin of the 'incomplete' *ballum* serotype.

Turtle sera with low *hyos*-titre, absorbed by *L. ballum*, lost their agglutinating power for both serotypes. Absorption by *L. hyos*, however, did not change the titre for *L. ballum*.

Preliminary investigations have been carried out in order to determine whether there are other properties in addition to agglutinating and lytic factors

which prevent infection by *L. ballum* in *Clemmys* sera.

Intraperitoneal infection in white mice with a mixture of two cultures of *L. ballum* resulted in prolonged presence of the organism in the kidneys, and its excretion in the urine of all the animals. No *Leptospira* were, however, found in mice that had been injected with the same culture to which a small amount of *Clemmys* serum was added.

These results strongly suggest that *Clemmys* sera contain immune bodies against the *Leptospira* mentioned. It appears that the capability of *Clemmys caspica* to produce *Leptospira*-agglutinating antibodies is very limited. Two turtles showed a titre as low as 50, and a third one reached only 1 : 100 after repeated injections of large quantities of *L. grippotyphosa* culture into its body cavity.

It seems desirable to investigate a possible relationship between the agglutination of *L. ballum* and *L. biflexa-Gent* in turtle sera.

After absorption with *L. ballum* (strain Castellon or *S* 102), the 'agglutinins' disappeared, not only for the *ballum* strains but also for the heterologous *biflexa-Gent* strain. Absorption with *L. biflexa-Gent* similarly eliminated the agglutinating power for both strains. This unexpected result is remarkable in the light of our experience with sera of rabbits, guinea pigs and land tortoises (*Testudo graeca*), which were immunized separately by repeated injection with *L. ballum* or *L. biflexa-Gent*. These immune sera contained agglutinins only for the strains injected, and absorption with the heterologous strain did not significantly affect the serum titre for the homologous serotype.

Sera of hedgehogs naturally infected with *L. ballum* and showing significant titres with this serotype revealed no agglutinins for *L. biflexa-Gent*.

It would thus seem that the agglutinating factor in *Clemmys* sera is based on a principle different from that of the immune antibodies. The origin and character of this factor and the mutual relationship between the *ballum* and *biflexa-Gent* agglutination are as yet obscure. Contrary to the positive results with the sera of *Clemmys caspica*, no agglutination was observed in blood samples of local land tortoises (*Testudo graeca*), soft water turtles (*Trionyx triunguis*) and water snakes (*Natrix tessellata*).

Similar results have been recorded recently by Combiesco *et al.*[1]. Six land tortoises did not reveal *Leptospira* antibodies, but ten out of eleven swamp turtles (*Emys orbicularis*) reacted strongly with *L. mitis* (probably syn. *L. hyos*). *Leptospira* were not isolated from the reacting animals. Injection of a virulent *L. icterohaemorrhagiae* culture produced only little agglutinin (titre 80–320).

Further investigation is necessary to determine the origin and nature of the agglutinating and protecting factors present in certain water turtles. As a working hypothesis, we assume that saprophytic water *Leptospira* play a part in the genesis of these factors.

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PATHOLOGY

Detection of Serum Proteins within the Renal Collecting Tubule Cells of the Potassium-deficient Rat

In potassium-deficient rats characteristic granules appear within the cytoplasm of the collecting tubule cells; the origin and nature of the granules have not been established. By labelling the serum proteins with the dye *T*-1824 it has been examined whether or not they might be made up, at least in part, of serum protein entering from the tubular lumen.

Solutions of *T*-1824, kindly presented by the Warner-Chilcott Laboratories, New York, were injected into the tail veins of twelve 200-gm. male Wistar rats (5 mgm./100 gm. body-weight of the rat) that had been made potassium-deficient by feeding for three weeks on a diet deficient in potassium. Twelve control rats on a similar diet adequately supplemented with potassium were also injected with dye. Rats from the experimental and control groups were killed 1, 2, 8, and 14 days after injection, and unstained frozen sections of the kidneys were examined microscopically. In the potassium-deficient rats killed 8 and 14 days after dye injection the collecting tubule cells contained blue granules; no such coloured granules were seen in this location in either the control animals or in the potassium-deficient rats killed 1 and 2 days after injection.

T-1824 is firmly bound to serum proteins under many varying conditions[1–4], and the blue granules in the collecting tubules are presumed to contain dye-tagged serum protein. Since the granules containing the dye were mostly at the side of the tubular cells nearest the lumen it seems probable that the dye-protein complex entered the cell from that direction. This conclusion is supported by the absence of coloration in the granules in rats killed 1 and 2 days after dye injection, as more prompt coloration might be expected to occur after *T*-1824 injection were the peritubular capillaries the source of the dye-protein complex.

It is known that when *T*-1824 is injected into normal rats it accumulates in droplet form within the proximal convoluted tubule cells of the kidney[1,2]; this has been related to the normal process of reabsorption of serum protein by the convoluted tubule cells[2,3]. There was a diminution in the number and intensity of *T*-1824 stained material in the convoluted tubules of all the potassium-deficient animals examined when compared with the controls; this suggests that the normal process of protein reabsorption by the convoluted tubule cells may be decreased in potassium-deficient rats. The attractiveness of this explanation is enhanced by the appearance of blue-coloured protein in the urines of the potassium-deficient animals injected with *T*-1824, while the urinary protein of the injected controls was uncoloured. In addition, in a separate experiment, it was demonstrated that potassium-deficient rats had a greater proteinuria than normal rats. This was done by measuring the urinary protein, precipitated by the method of Shevky and Stafford[5], in four male Wistar rats before and after potassium depletion; a two- to three-fold increase was found in the rate of protein excretion after the deficiency was established (Table 1).

It is concluded that potassium-deficient rats possess collecting tubule cells so altered by the deficiency as to permit the movement of serum protein from the

Table 1. Urinary Protein Excretion-rate of Rats before and after Potassium Deficiency

	During control period (mgm./hr.)*		During potassium deficiency (mgm./hr.)*		
	Day 1	Day 8	Day 13	Day 20	Day 27
Rat 1	0·20	0·42	1·70	1·60	0·88
Rat 2	0·09	0·22	0·54	0·99	0·45
Rat 3	0·33	0·43	1·13	0·83	0·70
Rat 4	0·59	0·32	1·20	0·83	0·73
Means	0·33	0·35	1·14	0·91	0·69

* All urine specimens analysed were 24-hr. collections.

tubular lumen into the cells, where it appears in the form of granules in the cytoplasm. This work supports the view[6,7] that the cytoplasmic granulations of the collecting tubules in potassium-deficient rats are not simply distorted mitochondria as has been claimed[8,9]. Potassium-deficiency also leads to a greater degree of proteinuria in the rat. This may result from a decrease in the proximal convoluted tubule reabsorption of protein, from changes in the glomerular filtration-rate, or from changes in the integrity of the glomerular filter.

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Variant of Parotid Tumour (Polyoma) Virus showing a Change in Oncogenic Properties

The striking differences, as reported by several laboratories, in the types and frequencies of lesions and neoplasms produced in the same inbred strains of mice by parotid tumour virus indicate the existence of different variants. Close antigenic relationships, however, have been established for many of the different 'strains' of virus.

In our laboratory a thymotropic strain of virus was isolated from a *C3H/Bi* mouse with a tumour. This strain has been propagated serially by passage in a tissue-culture cell-line (*P*-388 *D*1) derived from a lymphocytic neoplasm of *DBA*/2 origin. The origins of the tissue culture cell line and of the virus have been described[1,2]. The biological properties of the virus-strain have been reported in detail[3–4]. The tumour-inducing capacity of the virus, propagated by passage in *P* 388 *D*1, has been evaluated through the fifteenth passage material. This passage represents a total effective theoretical dilution from the starting material of approximately 1×10^{-45}. Throughout this period, this strain of virus has been strikingly virulent in its oncogenic properties, and it induced in *C3H/Bi* (*C3H* × *AKR*)F_1 and (*C3H* × *AKR*)F_2 mice nearly 100 per cent thymic epithelial tumours as early as sixteen days after neonatal injection. Many other primary sites besides the thymus have been involved in tumour induction. Parotid, submaxillary and sub-lingual salivary glands have been affected, as well as the lacrimal and thyroid glands and glands within the submucosal tissues of the trachea, oropharynx and nares. In addition, a lesion of the renal cortex, producing an alteration of the tubular epithelium[5], regularly results from the inoculation of this strain of virus[2].

At the time this polyoma virus strain was first introduced into *P* 388 *D*1 cell cultures grown in a medium containing 40 per cent human serum[3], the virus was also introduced into *P*–388 *D*1 cultures which had been adapted to grow in a serum-free medium containing non-fat milk[6]. Cytopathic effects in tissue culture, and induction of multiple sarcomatous and angiomatous lesions in hamsters and *Mastomys*, have been described for this virus strain after multiple passages in milk medium[7–9].

The tumour-producing capacity of polyoma virus passaged in *P*-388 *D*1 cells in a serum medium was compared with tumour-inducing capacity of virus after passage in the serum-free milk medium. Virus was collected from the combined fourteenth and fifteenth consecutive passages of each tissue-culture cell-line. Subcutaneous inoculations of 0·05 ml. into (*C3H* × *AKR*)F_1 and (*C3H* × *AKR*)F_2 mice less than 72 hr. of age were performed. Recipient mice were born of mothers having haemagglutination-inhibiting antibody titres of < 100. Under these conditions antibodies[4] would not interfere with tumour-inducing capacities.

Polyoma passaged in the 30–40 per cent human serum medium has consistently shown a low titre as measured by haemagglutination, tissue-culture infectivity and mouse-antibody production[10] determinations, but has maintained its high tumour-inducing capacity. The amount of $TCID_{50}$/ml. of the fourteenth-fifteenth passaged pool of *S* virus was $1 \times 10^{6.9}$ and of the *M* virus, $1 \times 10^{5.4}$; infectivity tests were run in parallel using *P*-388 *D*1 cells in a medium supplemented with 5 per cent calf serum. The number of haemagglutination units/ml. for serum and serum-free milk media was 100 and 2,500, respectively.

The comparative tumour-inducing effects are shown in Table 1 in mice observed over a 10–14-month period. In addition to the striking reduction in frequency of tumours induced by virus propagated in *P*–388 *D*1 cells grown in the milk medium, attenuation of tumour-inducing capacity was also indicated by the decreased number of primary tissue sites involved in tumour formation. Of the 2 mice which developed pleomorphic parotid gland tumours, one had a small thymic epithelial tumour; the other had parotid gland involvement only. In only one of the three mice with thymic epithelial tumours were any other primary sites of tumour formation found. In this mouse, small areas in the parotid gland tissue were altered. Of 14 mice which have come to autopsy in milk the medium group, only two showed definite renal lesion. There appeared to be, however, no attenuation of the oncogenic activity for hamsters of the polyoma virus passaged in *P*–388 *D*1 cells in milk medium. Four separate pools of virus, ranging in $TCID_{50}$/ml. from $10^{5.2}$ to $10^{7.2}$, induced characteristic tumours in hamsters as follows: 16 in 16, 5 in 6, 5 in 6 and 4 in 10 animals inoculated

Table 1. TUMOUR-INDUCING CAPACITY IN MICE OF PAROTID TUMOUR (POLYOMA) VIRUS OF TWO STRAINS HAVING A COMMON ORIGIN

Virus in medium	Dose of virus: mouse $TCID_{50}$	No. of litters from haemag. inhib.-negative mothers	No. of mice	No. of tumours*		Latent period in months (range)
				Thymus	Parotid gland	
Serum (14th–15th passages)	$1 \times 10^{6.7}$	5	43	28 (83·7 per cent)	8	3·3 (1½–6)
MK$_1$ (14th–15th passages)	$1 \times 10^{6.3}$	12	72	3 (6·9 per cent)	2	4·8 (1½–6)

* Sites of first appearance of tumours, grossly.

shortly after birth and subjected to autopsy afterwards.

The results reported here in which polyoma virus showed attenuation of tumour-inducing capacity for mice without obvious changes in tumour-inducing capacity for hamsters or infectivity for tissue culture and mouse tissues (antibody-production tests) are in contrast with the results reported by Sachs and Medina[11]. These authors observed attenuation of a strain of polyoma virus in its tumour-inducing capacities for both hamsters and mice without loss of cytopathic effect in tissue cultures.

Our findings may indicate selection of a genetic variant with little oncogenic activity in mice. They could also be explained on the basis of some change in protein coat of the virus. A third possible explanation is that a large amount of non-oncogenic virus is produced in the infected cells in milk-medium in association with a small amount of virus with oncogenic properties similar to those of virus grown in serum-containing medium. Inoculation of newly born mice with such a mixture might produce a rapid immune response and hence interfere with induction of tumours.

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RADIOBIOLOGY

Changes in Density of Blood Serum after Total-Body Irradiation

IT is known that the ionizing radiation causes changes in some physical-chemical properties in living organisms[1,2]. It is assumed that changes of the physical-chemical properties have an important bearing on the development of the post-irradiation

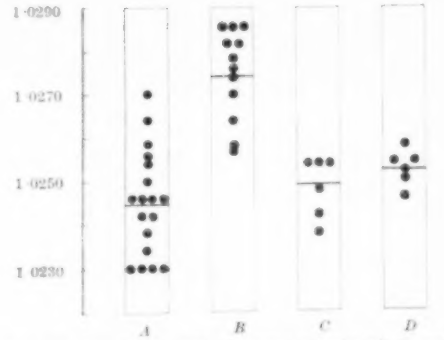

Fig. 1. Abscissa, density of blood serum; ordinate, col. *A*, control animals; col. *B*, animals irradiated by 600 r.; col. *C*, scorched rats; col. *D*, rats deprived of drink

syndrome. We have followed the changes in the density of blood serum.

The blood serum was obtained by decapitating rats and centrifuging their blood. Serum density was determined by measuring 0·25 ml. volume by means of a microburette manipulated with a micrometric screw and by weighing on an analytical balance. The microburette was kept at 20° C. The volume of the serum pressed out from the microburette was always calibrated by redistilled water.

The rats were irradiated by X-ray therapeutic Meta apparatus at 200 kV., 10 m.amp., 4 mm. aluminium filter, from a distance of 75 cm. in a rotating low wooden cylinder in which the animals were placed in individual boxes. The average radiation beam was 13·5 r./min.

Scorching was effected by putting a 4-cm.^{2} hot metal sheet on the back of the animals for 15 sec.

We examined the blood serum density in groups of six white laboratory rats, Wistar strain, of both sexes. The animals were fed on standard diet.

The results obtained in three control groups are indicated in Fig. 1, col. *A*. In Fig. 1, col. *B*, are the results obtained in two groups of rats irradiated with 600 r. The rats were killed 6 hr. after irradiation. In col. *C* are the results of the scorched-rat groups 6 hr. after scorching and in col. *D* representing the group of animals that were refused drink for 48 hr. before killing. In these experiments the density of the serum was deducted after previous 24 hr. incubation, at 4° C.

The convenient period of incubation was verified by measurement of the serum density after different

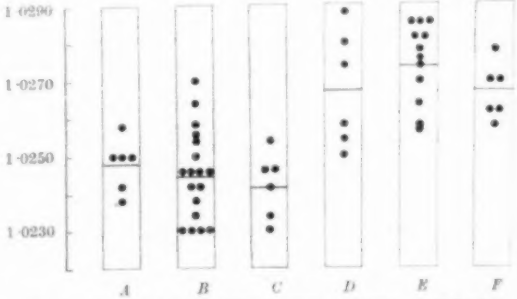

Fig. 2. Abscissa, density of blood serum; ordinate, control rats; col. *A*, serum density measured immediately after blood letting; col. *B*, density measured 24 hr. after serum incubation at 4° C.; col. *C*, density measured 48 hr. after serum incubation at 4° C.; irradiated rats dosed 600 r.

periods of storing, at different temperatures. While the stored serum in a thermostat, at 37° C., appeared to be inconvenient, incubation at 4° C. always yielded statistically significant results between the controlled and the irradiated animals.

In Fig. 2 are indicated the values of serum densities in three control groups after immediate decapitation of the animals (col. *A*), after 24-hr. incubation of the serum at 4° C. (col. *B*), and after 48 hr. incubation at 4° C. (col. *C*). In cols. *D*, *E*, *F* are values obtained in respect of three groups of rats after 600 r. irradiation, where the measurements were carried out under the same conditions as those of the control groups.

From these experiments it follows that after the total-body irradiation the blood serum increases in density. In the irradiated rats, in contradistinction to the controlled, as well as to the stressed animals, the differences are statistically significant. On the other hand the difference between the controlled and the stressed groups is not statistically significant.

We are examining the cause affecting post-irradiation increase in blood serum density. We believe that the cause may be due to the post-irradiation of nucleic acid katabolites because it is well known that these, especially deoxyribonucleic acid, are highly radiosensitive and they decrease in organs after irradiation[3,4]. Nucleosides and their precursors are represented in blood even under physiological conditions[5]. After irradiation an agglomeration of some of them occurs in a more considerable measure in blood and in urine excreted as in the case with deoxycitidine[6].

It is also possible to imagine that there is a correlation between sudden decrease of leucocytes after irradiation and the increase in serum density.

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Hæmagglutinin Production in Pre-immunized Mice exposed to Continuous γ-Radiation

Benjamin and Sluka[1] first showed that X-radiation in sub-lethal doses could depress precipitin titres in rabbits when the radiation was given just before administration of the antigen, but that when the radiation was given after the antigen the precipitin titres were not depressed to the same extent. Since that time many workers have confirmed these observations (for review, see Taliaferro and Taliaferro[2]). With smaller doses of acute whole-body radiation, the results have been more conflicting, some workers claiming that antibody production could even be enhanced by small doses of X-rays. Very few, if any, observations have been made on the effect of continuous, as opposed to intermittent, radiation on antibody production.

In this preliminary report of some observations on the effect of continuous γ-radiation on pre-immunized mice it is shown that, despite the accumulation of a large dose of radiation, hæmagglutinin titres are maintained at normal levels during the period of radiation and at higher levels for a period of time after radiation.

Thirty-two Strong *A* male mice 3–4 months old were divided into 2 groups of 16 mice each and each group further subdivided into 4 boxes of 4 mice each. All 32 mice were then given a single intraperitoneal injection of 0·1 ml. of packed, washed sheep red cells as a primary immunizing dose of antigen. Fourteen days later, all the mice were weighed and then bled from the tail to a maximum of 0·25 ml. of blood.

The serum was separated from each individual sample and hæmagglutinin titration of the serum was carried out in 'Perspex' trays with doubling dilutions of the serum in saline against equal volumes of a 3 per cent suspension of washed sheep red cells. After 60 min. incubation at 37·5° C. the end points were read under the low power of the microscope. Ten days after the first bleeding, the 16 mice to be irradiated were then placed in aluminium boxes in a special unit containing a central source of 6·7 c. cæsium-137 so that they were receiving a continuous daily radiation dose of 84 rad/day. A short description of this unit has been published elsewhere[3].

At weekly intervals, 2 mice were removed at random from the unit and, after weighing, were bled from the tail under anæsthesia for serum and then killed. Two control mice were bled in the same way each time a pair of radiated mice was removed from the unit.

After 31 days in the unit, during which time the remaining mice had accumulated a total of 2,604 rads, these mice were then removed. Pairs of mice from this group together with pairs of control mice were bled from the tail and killed at intervals for a further month.

Fig. 1 shows the change with time of the hæmagglutinin titres for both the irradiated and control groups. In all cases the change is expressed as the difference in logarithms of the titre at the time of killing and that determined for the same animal 14 days after the primary antigenic stimulus of sheep red cells and prior to the start of continuous radiation (in the case of the irradiated group).

During the period of radiation, although the mean increase in the titres of the irradiated group is higher than that of the control group, this difference is not statistically significant. However, in the post-irradia-

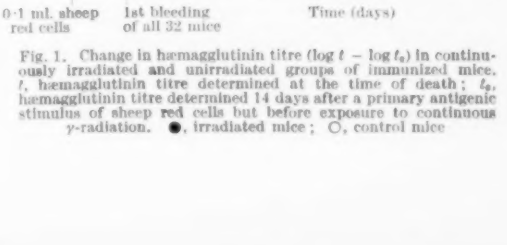

Fig. 1. Change in hæmagglutinin titre (log t − log t_0) in continuously irradiated and unirradiated groups of immunized mice. t, hæmagglutinin titre determined at the time of death; t_0, hæmagglutinin titre determined 14 days after a primary antigenic stimulus of sheep red cells but before exposure to continuous γ-radiation. ●, irradiated mice; ○, control mice

tion period there is quite clearly a statistically significant difference at the 5 per cent level between the two groups.

From the results of the present experiment, the time of onset of this difference between the two groups is not readily apparent. However, the results of a small preliminary experiment in which mice were immunized with sheep red cells and exposed to radiation in the same way, but in which the sera were obtained from consecutive bleedings of the same animal, indicated that this relative increase in haemagglutinin titre in the irradiated group could be demonstrated towards the end of the period of radiation and persisted well into the post-irradiation period.

The maintenance of normal haemagglutinin titres during continuous irradiation indicates that antibody-producing mechanisms are not seriously disturbed despite the accumulation of relatively large doses of radiation, and the fact that antibody titres are sometimes higher than before radiation suggests that active antibody production is still in progress and that it is not merely preformed antibody-levels which are being measured.

It is unlikely that the maintenance of antibody-levels is merely a reflexion of the destruction of large numbers of lymphoid cells, with the consequent liberation of antibody as was suggested by Dougherty, Chase and White[4], following the injection of pituitary adrenotrophic hormone, since during continuous irradiation the peripheral white blood count falls to low levels within a few days at this dose-rate, and remains low throughout the period of radiation and for some time afterwards. Moreover, Marshall and White[5] failed to detect increases in circulating antibody following the destruction of lymphocytes by nitrogen mustard.

It seems likely, therefore, that some other relatively radioresistant cell belonging to the reticulo-endothelial system is responsible for antibody production.

Hill[6] has described the development of increasing pyrinophilia of the reticular cells of lymphoid tissue and the development of immature plasma cells following doses of 500 r. whole-body radiation. Nossal[7] has also observed marked plasma cell proliferation in rats following single doses of 500 r. whole-body radiation and considers that the plasma cell is more radioresistant than the lymphocyte. Preliminary histological studies of the spleen and lymph nodes in the present experiment suggest that plasma cell proliferation is also taking place in these continuously irradiated mice. These observations and their relationship to antibody production will be reported in more detail elsewhere.

I should like to acknowledge the help and encouragement I have received from Prof. W. V. Mayneord, head of this Department.

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BIOLOGY

Incorporation of Tritium-labelled Thymidine in *Bufo* ♀ × *Rana temporaria* ♂ Hybrid Embryos

It is well known that cross-fertilization can often be performed in amphibians; development, in anurans, often does not proceed further than the late blastula or early gastrula stage. The reasons why this block in development occurs are not yet well known. I hoped that an autoradiographic study of the incorporation of nucleic acid and protein precursors into lethal hybrids might help in elucidating the problem. The precursor used in this work is tritium-labelled thymidine. B. C. Moore[1] has shown that this precursor, if injected into female *Rana pipiens* before ovulation, is incorporated, at the morula stage, in the nuclei of normal *Rana pipiens* and of androgenetic *pipiens* embryos. Thymidine is also incorporated into the deoxyribonucleic acid of the lethal diploid hybrids *pipiens* ♀ × *sylvatica* ♂.

The incorporation of labelled precursors into amphibian embryos is limited by the presence of the surface coat which renders the embryo nearly impermeable to a large number of substances. In order to rule out this permeability problem, we have worked on embryos the coat of which had been disintegrated in a medium devoid of calcium ions.

The embryos at the 2-cells stage were incubated in the following medium: sodium chloride (17 per cent) 20 ml.; potassium chloride (0·5 per cent) 10 ml.; water 966 ml.; *tris* 560 mgm.; *N* hydrochloric acid 4 ml.; sodium citrate 5 gm. Tritium-labelled thymidine was added at a concentration of 5×10^{-6} *M* (2·5 mc.). After a 17-hr. incubation, the embryos were fixed by freeze-substitution[2] and the incorporation was studied by the autoradiography technique of A. Fieq[3].

In the lethal combination studied in the present work, the embryos stopped development at the late blastula stage. The incorporation was investigated at the time of the arrest of development and 24 hr. later. The controls were at the gastrula and at the neurula stage respectively. In these experiments, I have followed Barth's[4] directions concerning the dissociation of the cells and the culture medium. The embryos, deprived of the vitelline membrane, were first incubated in the dissociating medium; after dissociation, they were placed in the culture medium containing labelled thymidine. The cells were fixed, after a 90-min. or a 24-hr. incubation, with a mixture of acetic acid and alcohol (10/90 v/v) and put through the autoradiography procedure.

Thymidine was found to be incorporated into the nuclei, and nearly all the radioactivity could be removed by deoxyribonuclease (0·1 mgm./ml. in *tris* buffer *p*H 7·5 containing Mg^{2+} *M*/300—1 hr. at 37°); on the other hand, there was no diminution of radioactivity following a ribonuclease treatment (0·2 mgm./ml. in *tris* buffer *p*H 7·5 containing Mg^{2+} *M*/300—1 hr. at 37°). In the arrested blastulæ, we have observed the cytological abnormalities already described by Brachet[5]; in several nuclei the chromatin sticks to the nuclear membrane, where it forms a thin layer; the radioactivity is associated with this area. Sometimes, labelled chromatin is found in the cytoplasm. Finally, the nuclei often consist of two hemikaryons which can be distinguished by their staining properties towards methyl green and

pyronine; in this case, there is a good correspondence between methyl green staining and the number of silver grains in the emulsion.

Labelling of deoxyribonucleic acid could thus be observed in morula as well as in blastula cells of the lethal hybrids. Moreover, 24 hr. after development stopped, tritium-labelled thymidine was still incorporated into deoxyribonucleic acid, a fact which suggests that the block in development is not due to the arrest of deoxyribonucleic acid synthesis. Such a conclusion has already been reached by Løvtrup and Gregg[6], for the similar *Rana pipiens* ♀ × *Rana sphenica* ♂ combination, on the basis of biochemical measurements of deoxyribonucleic acid synthesis.

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Chloride-secreting Cells in the Gills of European Eels

In a recent communication Parry, Holliday and Blaxter[1] reopened the question of the chloride-secreting cells of the gills of fish and, in agreement with Bevelander's[2] arguments, they brought new indirect evidence against Keys and Willmer's theory[3] and Copeland's[4] conclusions.

Eels provide an excellent material for direct investigation of this point: Keys[3] demonstrated that branchial chloride is excreted by animals adapted to sea-water: whether chloride absorption occurs is doubtful[5]. Moreover, silver eels migrate from fresh water to the sea and this behaviour should be related to a change in osmo-regulative capacities.

Gills of yellow and silver eels, adapted to fresh and sea-water, have been studied with Leschke's histochemical test for chloride. Although Leschke's method lacks specificity and is reproducible only within rather wide limits (cf. Lison[7]), a comparison of results obtained with identical tests in standard conditions from different animals can give reliable information.

The acidophil cells of yellow eels living both in fresh and in sea-water gave a positive chloride test, although slight and somewhat variable. With silver eels, the chloride test was strongly positive (Fig. 1) for animals adapted to sea-water, but clearly negative for those maintained in fresh water (Fig. 2).

These results confirm Keys and Willmer's theory and Copeland's data (on *Fundulus*) of the role of the acidophil cells of the gills of some fishes in chloride secretion, and demonstrate a different osmo-regulation between yellow and silver eels.

Yellow eels appear to be more euryaline and capable of secreting and absorbing chloride through the gills, but this conclusion should be confirmed by physiological experiments on eels of a definite stage of development. Silver eels seem to be able to secrete but not to absorb chloride by the gills.

These differences in osmotic function between yellow and silver eels explain the migration of silver eels from fresh water to the sea more clearly than the 'demineralization' theory postulated by Fontaine[8].

Fig. 1. Longitudinal section of gill filament of a silver eel adapted to sea-water. The acidophil cells at the base of lamellæ show a positive test for chloride, with Leschke's method. (× 300)

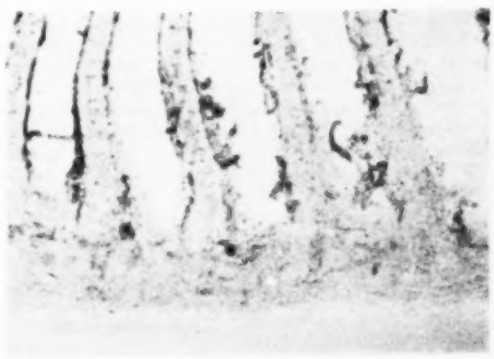

Fig. 2. Longitudinal section of gill filament of a silver eel adapted to fresh water. Leschke's test is negative. (× 300)

Silver eels can also survive in fresh water; the salt balance in this environment is likely to be maintained by the larger amount of water swallowed. Indirect evidence of this fact comes from Defrise's[9] experiments, which show that, in fresh water, (silver?) eels produce more than ten times as much urine as sea-adapted eels.

A full account of this research is in the press[10].

I am indebted to Prof. U. D'Ancona for suggestions and criticisms.

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Photoperiodicity of Seasonal Rhythm of Wool Growth in Sheep

The existence of a seasonal rhythm of growth of wool of sheep on a uniform diet was first shown in 1949 by Ferguson, Carter and Hardy[1]. These authors and Wodzicka[2] present indirect evidence which suggests that this rhythm, with maximum growth in summer and minimum in winter, is induced mainly by seasonal changes in temperature. However, certain photoperiodic responses in wool growth reported by Coop and Hart[3] and by Hart[4], together with the proof by Yeates[5,6] that the seasonal breeding-cycle in sheep is photoperiodically controlled, suggested that seasonal changes in length of day should be investigated in some detail as a possible cause of the seasonal wool growth cycle. The following experiment was therefore carried out.

Three groups of mature non-pregnant Romney Marsh ewes were fed a uniform ration of lucerne chaff which was sufficient to maintain a slight steady increase in body-weight. The control group was kept under environmental conditions (sub-tropical) normal to Brisbane. The second group remained under normal environmental temperature conditions but was subjected to an accentuated reversed rhythm of seasonal changes in length of day as used by Yeates[6] and illustrated in Fig. 1. The third group received normal hours of daylight but was exposed to a somewhat reversed seasonal temperature-cycle as shown in Fig. 2. It was not possible to arrange an ideal reversal of seasonal changes in temperature for this third group, owing to other projects using the controlled-temperature rooms at the same time.

The experiment started with 8 sheep in each of the three groups, but during the 2 years of the experiment a total of 6 sheep died, and during the second year two suffered a marked decrease in body-weight and were therefore excluded from the experiment. This left 16 sheep (4 controls, 7 in the reversed day-length group and 5 in the reversed temperature group) which remained in good condition throughout the experiment, and from which the wool growth curves in Figs. 1 and 2 were compiled. It was observed that each of the eight sheep finally excluded because of death or loss of weight closely followed the wool growth rhythm of its respective group while it remained in good condition.

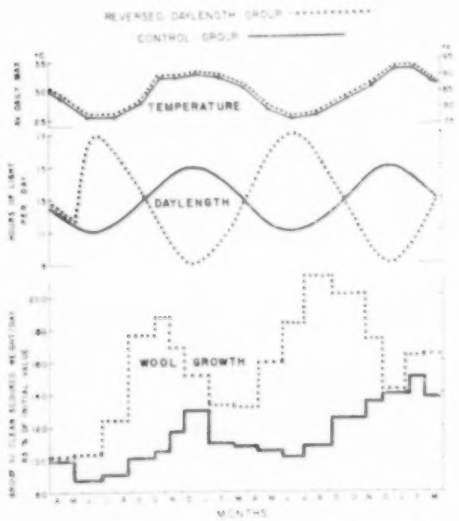

Fig. 1. Temperature, day-length and wool growth curves for the control group of 4 ewes (——) and the reversed day-length group of 7 ewes (. . . .). Reversal of the day-length cycle caused complete reversal of the wool growth-cycle

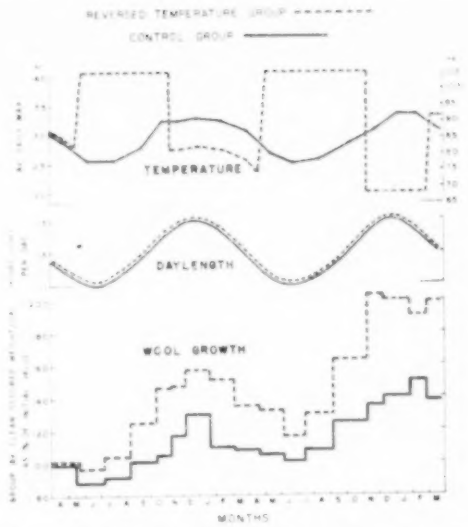

Fig. 2. Temperature, day-length and wool growth curves for the control group of 4 ewes (——) and the reversed temperature group of 5 ewes (– – –). An ideal reversal of the seasonal temperature cycle was not possible, but it can be seen that heating the latter group in winter and cooling them in summer had no obvious effect on the wool growth-cycle

Wool samples were clipped at approximately 6-week intervals from a 100 sq. cm. tattooed area on the mid-side of each sheep. The group averages of clean scoured weight/day for each growth period are shown in Figs. 1 and 2 as percentages of the initial average for the respective group. Fibre-diameter and staple-length were measured on the samples at selected periods during the experiment.

The following results were obtained:

(*a*) The control ewes showed a minimum wool growth-rate in winter and maximum in summer, as found by other workers[1–4].

(*b*) The ewes subjected to the reversed seasonal day-length rhythm developed a reversed seasonal wool growth rhythm with maximum wool growth in winter and minimum in summer. This reversal of wool growth rhythm occurred gradually, and took two years to complete.

(*c*) The reversal of the clean scoured weight rhythm resulted from a reversal of the rhythms of both fibre-diameter and staple-length.

(*d*) Upsetting the normal seasonal temperature cycle in the third group had no obvious effect on the wool growth-cycle of this group.

(*e*) The seasonal variation in wool growth was greatest in the reversed day-length group, a result which can reasonably be attributed to the greater seasonal variation in day-length experienced by this group.

(*f*) The overall increase in wool growth-rate over the 2 years was greater in the reversed day-length and temperature groups than in the control group. It is not known whether this is a direct result of the

experimental treatments, the result of some other factor such as the more secluded environment in the reversed day-length pen and the controlled temperature rooms, or simply a result of chance.

The most significant of the above findings is the reversal of the seasonal rhythm of wool-growth by a reversal of the seasonal rhythm of day-length. This means that progressively decreasing day-lengths decrease wool growth and increasing day-lengths increase it, regardless of temperature changes. It is concluded therefore that the seasonal wool growth-cycle is induced primarily by seasonal day-length changes and not by seasonal temperature changes. Further evidence supporting this conclusion is provided by the temperature experiment illustrated by Fig. 2, in which the natural wool growth-cycle was not obviously altered by heating the sheep in winter and cooling them in summer.

The fact that 2 years of exposure to a greatly accentuated reversed day-length rhythm was required to reverse completely the wool growth rhythm shows that the light-induced wool growth rhythm is difficult to alter, and this is probably why Wodzicka[2] was not able to eliminate the natural seasonal wool growth-cycle simply by subjecting sheep to a uniform day-length régime for 12 months. The effect of temperature on wool growth-rate should be studied in some detail, and with due regard to the persistence of the light-induced rhythm, since it is clear from the results reported here that the temperature effect, if one exists, is not very marked.

The suggestion that a high level of adrenocortical activity in winter might cause the natural decline of wool growth during this season (Lindner and Ferguson[7]) now seems unlikely, since the seasonal cycle of wool growth is light-induced whereas the seasonal cycle of adrenocortical activity seems to be induced by temperature and not by light (Robinson and Morris[8]).

This work will be published in more detail at a later date.

I sincerely thank the Wool Research Trust Fund (Australia) for financing this project.

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Elminius modestus on the South-East Coast of Scotland

Elminius modestus Darwin was first recorded in Britain in 1947 by Bishop[1], who found it to be well established in Chichester Harbour. Since that date numerous reports have been published giving the spread of this immigrant barnacle afterwards around the coasts of the British Isles.

Table 1. Population Densities of *Elminius modestus* at Various Stations in the Forth and Tay Areas

Forth Area

	South shore	Adults	Juveniles		North shore	Adults	Juveniles
				12	Kincardine Bridge	*A*	—
11	Blackness	*A*	*A*	13	Charlestown	*A*	*A*
10	South Queensferry	*A*	*B*	14	North Queensferry	*B*	*B*
9	Cramond	*B*	*B*	15	Aberdour	*C*	*D*
8	Portobello	*B*	*A*	16	Kinghorn	*B*	*B*
7	Gosford Bay	*B*	*B*	17	Kirkcaldy	*B*	*B*
6	Gullane Bay	*B*	*B—C*	18	East Wemyss	*B*	*C*
5	North Berwick	*C*	—	19	Elie	*D*	—
4	Belhaven	*D*	—	20	Anstruther Easter	—	—
3	Dunbar	*D*	—	21	Crail	—	—
2	Reed Cove	—	—				
1	Eyemouth	—	—				

Tay and St. Andrews Area

		Adults	Juveniles
22	St. Andrews	*D*	—
23	Tayport	*D*	—
24	Newport-on-Tay	—	—

Grades. *A*, Found with ease, population estimated as more than 10 per cent; *B*, found without difficulty, population estimated as more than 1 per cent; *C*, found fairly easily, either as isolated specimens or small groups fairly widely spaced; *D*, found only with difficulty after some minutes searching, usually isolated specimens; —, none found after searching for about 10 min. at each of three or four suitable places. In each grade the numbers of juveniles are slightly higher than those of the adults.

This spread was relatively rapid in most parts of England and Wales but in the north-east, about 1951, it ceased abruptly at the mouth of the Humber[2]. A recent report by Crisp[3] states, however, that *Elminius* has now been found as far north as the mouth of the River Tees.

In October 1960 I found numerous mature specimens of *Elminius* and a fairly recent but heavy settlement of spat at Portobello, on the south shore of the Firth of Forth. Dr. Crisp, in a private communication, has since confirmed the occurrence of the barnacle in this area, settlement having occurred on test panels immersed at Rosyth between August 24 and September 7; and October 3 and 27, 1960.

Therefore, in October and November 1960 I made an extensive but fairly rapid survey of the Forth estuary to determine the local limits of distribution of *Elminius* and to estimate roughly the proportion that it forms of the total barnacle population. The results of this survey are shown in Table 1 and Fig. 1.

A clear distribution pattern appeared on both shores of the Firth of Forth. The highest proportion of *Elminius* was found to the west of the Forth Bridge, at Queensferry, diminishing steadily towards the eastern, open end of the estuary. *Elminius*

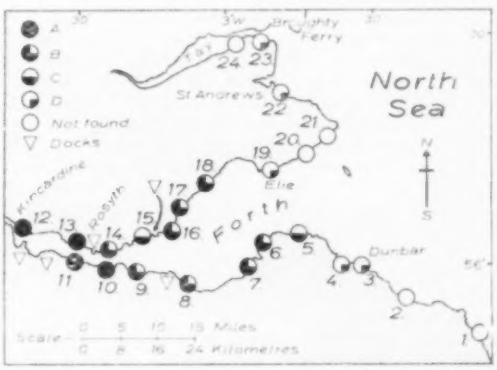

Fig. 1. Distribution of *Elminius modestus* Darwin in south-east Scotland. For key to station numbers and symbols see Table 1

extended slightly farther east on the south coast (Dunbar) than it did on the north coast (Elie). In addition, this barnacle was found in small numbers at St. Andrews and at Tayport, at the south-east end of the Tay estuary.

The distribution of the most recently settled larvæ followed a similar pattern to that of the adults but was less extensive. The young stages were more numerous on the south shore of the Forth, but a comparison of their sizes suggests that settlement had probably occurred earlier and persisted over a longer period on the north shore.

It seems likely that the focal point of the colonization of the Forth area developed as a result of remote dispersal[1] by ships, since it appears to have been centred on the inshore western end. Even if the settlement in the Tees area[2] were not of recent date, the distance and the nature of the intervening coast make it unlikely that marginal (that is, coastal) dispersal could have been responsible, since the maximum possible distance across which the animal can be dispersed by such means appears to be not more than about thirty miles[3].

The exact locality of the original Forth settlement must remain a matter for conjecture as there are numerous docks which take shipping from warmer waters (Fig. 1); perhaps the most likely possibility is the naval dockyard at Rosyth. In addition, there is a number of smaller fishing and sailing harbours which could have assisted in the subsequent local spread.

It is difficult, also, to estimate the probable date of the arrival of the initial colony or colonies. In 1956 Dr. Crisp failed to find *Elminius* at Portobello and Queensferry, where it is now common, but the present density and extent of the populations suggest that at least two, or possibly three, seasons have passed since the barnacle first became established. The rate of colonization may have been influenced in the early stages by the size of the original settlement, or settlements, and possibly by later introductions; but an initial period of build-up is necessary in order to produce the large numbers of larvæ requisite for dispersal and settlement in the area. It is likely that growth and reproduction will be slower in the colder latitude of the Forth than in the southern parts of Britain, where Crisp[2] suggested that the rate of colonization by marginal dispersal along an open coast is about 20–30 km. per annum. On consideration of these facts, therefore, it seems probable that the initial settlement occurred in 1958; a consolidation of the settlement and an extension in the enclosed waters to the west and the immediate east of the Forth Bridge may have occurred during the warmer summer in 1959; and the extension in quantity to the open part of the Firth in 1960.

The earliest record of *Elminius* on the east coast of Scotland comes from Dr. G. A. Horridge, of the Gatty Marine Laboratory, who, in a private communication, reports that it was noted at St. Andrews in 1958. Dr. Crisp, however, was unable to find the species at Broughty Ferry, Arbroath or Montrose, all north of the Tay, in February 1960.

The past history of the *Elminius* populations of this area is therefore far from clear, but it seems likely that the species will become established over a wider area of the east coast of Scotland with its numerous small harbours and sheltered coves. Although only recently established, the population in the Forth area has already become more numerous than the former dominant species, *Balanus balanoides* L., at some points, namely Blackness Point, Kincardine Bridge and Charlestown.

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Bathynella and Other Interstitial Crustacea in Southern England

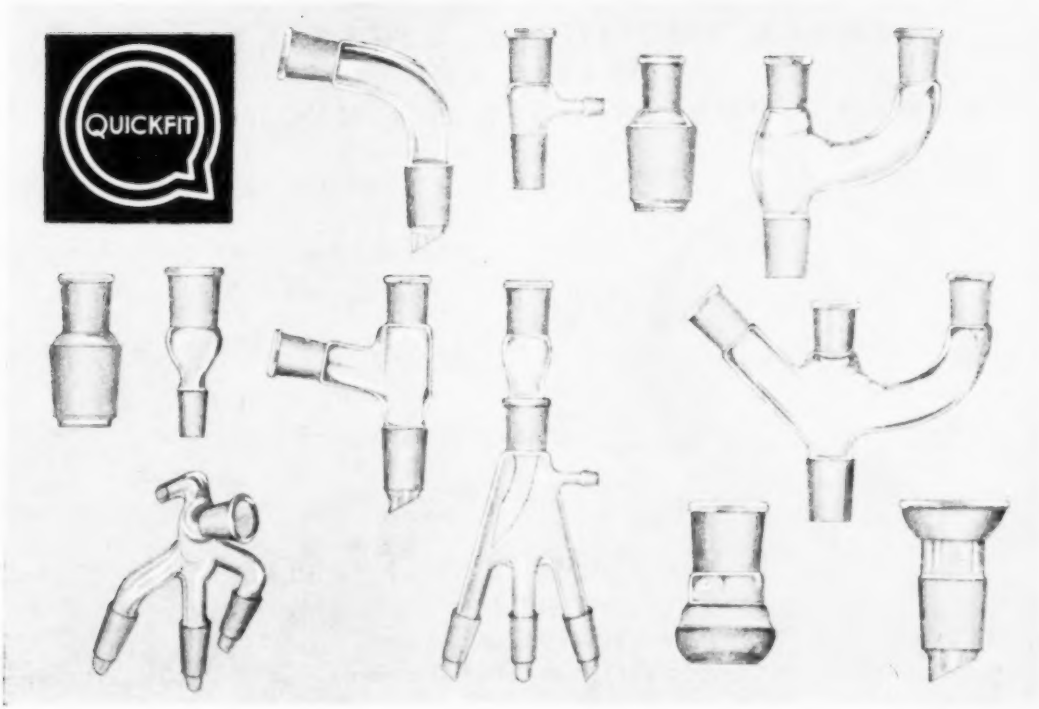
The report of a specimen of *Bathynella* from near Oxford[1] was a reminder that in Great Britain zoologists have still neglected to study the fauna inhabiting the interstitial water of strata below ground, though the potential interest of this habitat was clearly pointed out by A. G. Nicholls as long ago as 1946[2].

More recent work on the Continent, as, for example, that of Husmann[3] in Germany, is beginning to throw light on the nature of this fauna and how its members are distributed, at least in the more accessible sites. It has been realized for some time that several small 'hypogean' animals that occur sporadically in wells or cave water are really generally spread in interstitial water of strata bathed by a permanent water-table, and indeed primarily belong to this habitat. The crustacean family Bathynellidae provides perhaps the most striking example. About thirty species, classified in five genera, are now known from various parts of the world, including Eurasia, Africa, South America and Madagascar. Few of them greatly exceed 1 mm. in length and being very narrow are well suited for moving through not only gravels but also coarser sands. Throughout central Europe, eastward to Roumania, one species[4]—*Bathynella natans* Vejdovsky (= *chappuisii* Delachoux)—has been found in interstitial ground water in many places where it has been sought. Its status in Britain might be presumed to be the same, but evidence has been lacking.

Among other crustacean genera known from underground interstitial water in central or southern Europe are three (*Microcharon*, *Ingolfiella* and *Bogidiella*) that are represented in marine gravel on the bed of the English Channel[4]. This find raises such questions as whether these genera may not also be represented in sub-surface fresh water in Britain, and, more generally, whether there is not a transition zone where sub-surface fresh water grades into that held in strata below the sea bed, making possible a gradual exchange of fauna between the two.

More information is needed from the landward side, and, in pointing out this neglected field, and urging that fresh water biologists might profitably turn attention to it, I can report the results of some tentative steps I have myself been taking in this direction.

Attempts to sample ground-water have been made in three ways: (1) by filtering water delivered by an electric pump through a pipe driven into water-bearing gravel; (2) by washing stones and gravel at the point of issue of hill-slope springs; and (3) by digging shallow pits in gravel where the water-table is high.



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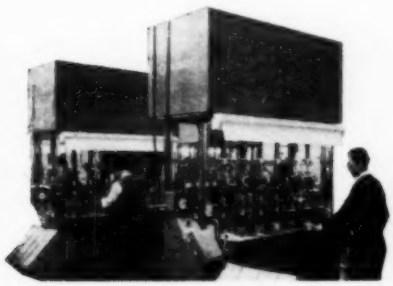

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such as in the ox-bow of a river. Each of these methods, simple though they are, produced encouraging results at the first attempt, particularly with regard to the crustaceans collected. Three species in particular deserve mention.

Bathynella natans Vejd. Examples have been collected by all three techniques. (1) At Whitchurch (Oxon), in the Thames valley opposite Pangbourne (Berks), through an opportunity kindly presented by Dr. I. H. H. Yarrow (to whom and to whose family I am extremely indebted for help), an estimated volume of 3,400 gallons of water raised from the alluvial gravel, on April 2 and 3, 1960, and filtered through a fine-meshed plankton tow-net, produced ten specimens. Here a 1-in. metal pipe had been driven 14 ft. into the ground and an electric pump delivered water through it at the rate of about 500 gallons an hour. The pump had not been used for nearly a year. The catches were distributed over the two days.

(2) One of the two springs emerging in fields (owned by my colleague, Dr. J. A. C. Nicol) at Moortown, near Tavistock, Devon, on the slope of Dartmoor, produced a single adult *Bathynella*, when sampled on May 3. This site is at 560 ft. O.D., on metamorphosed slate, and about half a mile from the edge of the main granite outcrop. At the point of issue of the water a rough conduit had been made with flat stones, under which the water flowed over a small accumulation of stones and gravel some inches thick. Handfuls of the latter were swilled in a bucket and the water strained off.

(3) A pit was dug in a gravel spit alongside the River Plym, a little way above Cadover Bridge, in the granite area on the south-west side of Dartmoor, at 696 ft. O.D. Ground-water was reached just below 1 ft. and the gravel dug out for another foot. The gravel removed, consisting mainly of granite fragments with little detritus, was washed and the washings strained off, as well as much water that constantly seeped into the pit. The fauna collected included twelve specimens of *Bathynella*, mostly juvenile. A second pit, dug close at hand on May 27, in warmer weather, yielded two specimens at the lowest level dug. These observations are of interest in showing that *Bathynella* tolerates the acidic, peaty and very soft water for which Dartmoor is notorious.

On these findings, scanty as they are, it is difficult to escape the conclusion that *Bathynella natans* must be very widespread in water-holding strata through much of Britain. The gravels of the London basin may be expected to hold a large population. The zoological departments of some universities must be in a position to obtain a ready supply by simply boring into the gravels on which their buildings rest.

Niphargus glenniei Spooner. This small member of the amphipod genus of 'well-shrimps' was described from the limestone caves of Buckfastleigh and Ashburton (Devon)[6], which had remained the only known habitat. Several examples, however, have been obtained during this investigation. Two came from the Moortown spring that produced the *Bathynella*, and five from another spring at 700 ft. O.D. and nearer the granite. The second pit dug by the River Plym, in granite gravel, produced four specimens. Another example was got from a well on the edge of Dartmoor, near Wrangaton. Evidently, therefore, this species must be widely spread, in Devonshire, in interstitial ground-water, tolerating a wide range of *p*H. It seems to be the counterpart of *Niphargellus* spp. on the Continent.

Crangonyx subterraneus Bate. One of these amphipods was obtained from the water pumped at Whitchurch (as described above). Since first recognized by Spence Bate more than a hundred years ago, from a pump, there seem to be only two subsequent occurrences in Britain (one from a well, and one from a cave pool). The apparent scarcity would be explained if this species also proved to be primarily an inhabitant of interstitial water, and accidental elsewhere.

Granted that crustaceans of this sort, along with certain copepods, ostracods, mites, oligochaetes, nematodes, etc., regularly inhabit interstitial water, it may be asked how far do they range, or how deep into the geological strata do any of them penetrate.

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Soil *p*H and Mycorrhiza Development in *Pinus*

Mycorrhizas of *Pinus* will not develop profusely on trees growing in neutral or alkaline soils, and it has usually been assumed that this is so because the mycorrhizal fungi are acidophilic. During investigations of the fertility status of a nodular podzolic soil from the coastal lowlands of southern Queensland, I have found that formation of mycorrhiza in pine seedlings is not always inhibited by a rise in soil *p*H, and when it is, the effect can usually be explained in terms of host nutrition. The direct effect of alkalinity in restricting the growth of the fungus may be less important than was formerly thought. These results are derived from a series of pot experiments designed primarily to test for nutrient deficiencies, but also to study the effect of nutrient supply on the degree of mycorrhizal infection of seedlings. Comparison of relative mycorrhiza development was based on the number of mycorrhizas expressed as a percentage of the total number of short roots per seedling ('mycorrhiza per cent'). The criterion of infection used was the presence of dichotomous branching or forking of the short roots. Since dichotomy of short roots of *Pinus* is not always associated with mycorrhizal infection, some care is necessary in accepting forked short roots as mycorrhizas. Experience has shown that it is possible to recognize mycorrhizas of *Pinus* on the basis of their external morphology. In the work reported here, counting was carried out initially under a stereo-microscope (× 12·5), and after experience had been gained in this way a binocular loupé was used.

The forked mycorrhizas of the seedlings examined were predominantly of Melin's type *A* which, as described by Robertson[1], occur in acropetal succession on the parent long root. Type *B* mycorrhizas were far less common and these were counted along with the former type. Where any doubt existed, the short roots were regarded as uninfected. This also applied

Table 1. Effect of Ammonium Nitrate and Calcium Carbonate on Soil Nitrate-Level, Soil *p*H, and Mycorrhiza Development of *P. caribaea* (Experiment sown, April 30, 1957)

Treatment	Nitrate as p.p.m. nitrogen (June 10, 1957)	*p*H (Nov. 19, 1957)	'Mycorrhiza, per cent'* (Nov. 19, 1957)
Nil	12·7	6·3	19·5 (25·83)
Calcium carbonate, 16 cwt./acre	21·3	7·5	8·7 (16·86)
Ammonium nitrate, 3 cwt./acre	71·4	5·8	2·0 (7·21)
Calcium carbonate, 16 cwt./acre + ammonium nitrate, 3 cwt./acre	115·3	6·9	4·3 (8·19)
Significant difference ($P < 0·05$)	12·8	0·2	(5·26)
($P < 0·01$)	17·6	0·3	(7·25)

* Mean arc sine transformations shown in brackets.

to unbranched mycorrhizas: while these could frequently be recognized under the stereo-microscope, their identification by means of the binocular loupé was by no means certain. Full details of this work will be published elsewhere, but in the meantime the results can be summarized as follows: (1) Lime-induced chlorosis of *P. taeda* L. occurred at *p*H 7·5 and the seedlings had relatively few mycorrhizas. Normal mycorrhiza development was restored by adding the iron complex of ethylene diamine tetra-acetic acid to the soil without altering its *p*H; (2) both ammonium nitrate and calcium carbonate reduced mycorrhiza development in *P. caribaea* Mor. Calcium carbonate promoted nitrification, and as the nitrate-level in the soil increased, 'mycorrhiza per cent' declined, irrespective of whether soil *p*H increased or decreased (Table 1); (3) ammonium nitrate greatly reduced 'mycorrhiza per cent' of *P. taeda* growing at *p*H 5·5, but sodium carbonate did not affect mycorrhiza development even though it raised soil *p*H to 7·4; (4) sodium nitrate retarded mycorrhiza formation in *P. taeda*, and the greater the amount added, the longer the delay in mycorrhiza formation; (5) in an experiment designed to separate the effect of the sodium and nitrate ions, it was found that sodium ions did not affect mycorrhiza development in *P. taeda* even though they increased soil *p*H, whereas nitrate ions greatly reduced 'mycorrhiza per cent' (Table 2).

These experiments were all carried out using the closed pot system, that is, the pots were undrained. Because of this, no nitrate could be lost through leaching; nor was any evidence of denitrification encountered. It seems therefore that mycorrhiza formation in *P. taeda* and *P. caribaea* is not inhibited in neutral or slightly alkaline soils, provided the soil nitrate-level is low. That this has not been recognized previously may be due to the fact that mineralization of nitrogen proceeds rapidly in such soils.

Table 2. Effect of Sodium Nitrate and Sodium Carbonate on Soil *p*H and Mycorrhiza Development of *P. taeda*

Treatment	*p*H	'Mycorrhiza, per cent'*
Nil	6·5	33·6 (35·28)
Sodium nitrate	7·0	9·2 (14·92)
Sodium carbonate	7·0	22·9 (29·29)
Sodium nitrate + sodium carbonate	7·3	11·3 (17·14)
Significant difference ($P < 0·05$)	0·1	(7·60)
($P < 0·01$)	0·1	(10·19)

* Mean arc sine transformations shown in brackets. 10 ml. *N*/10 solution of each salt applied per pot.

The depressive effect of readily available nitrogen on mycorrhiza development may also explain why mycorrhizas are less abundant in mull soils than in mor. Although not necessarily more alkaline than mor soils, mulls nitrify well and have a higher content of ammonium and nitrate nitrogen in the natural state[3].

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ENTOMOLOGY

'Preferred Temperatures' of Land Arthropods

Studies on arthropod behaviour have often been concerned with the 'preferred temperatures' of the animals and attempts have been made to correlate results with the microclimatic changes in the animal's natural environment. It appears, however, that insufficient attention may have been paid to the other physical factors the variations of which cannot be easily eliminated from a temperature gradient. These factors have sometimes been assumed to be unimportant or have been disregarded altogether, and a preference shown by the animal for a particular zone within a temperature gradient apparatus has been attributed solely to temperature.

The main purpose of this communication is to point out that variables may exist in most of the usual types of closed temperature-gradient apparatus. For example, even in a gradient apparatus designed for observing small arthropods of 1·5 mm. × 1 mm. or less, the air temperature differs by more than 3 deg. C. from that of the floor. The air will be cooler than the floor at the 'warm half' and warmer than the floor in the 'cool half' of the temperature gradient. These differences will cause a 'thermal flow' from the warm end to the cool extreme with, at high humidities, the deposition of water droplets on the roof of the warm region and on the floor of the cool end.

It is often assumed that 'saturated air' may be easily produced and thus uniform humidity conditions obtained throughout a temperature gradient. However, if the air temperature is higher than that of the floor, the air in fact will not be completely saturated, although if the floor is warmer than the air the relative humidity will be 100 per cent. The rate of evaporation at any point in the apparatus can be determined by introducing there a modified Piche micro-evaporimeter; because the warm air flows into the cool region, evaporation may be much higher at the cool end than at the warm end.

Animals introduced into such an apparatus will consequently be acted on by (*a*) floor temperature, (*b*) air temperature, (*c*) thermal air currents, (*d*) differences in relative humidity and (*e*) evaporating gradients. All these factors, in addition to others depending on the physiological state of the organisms, must be considered in the interpretation of any results.

I have been concerned with aspects of the physiology and ecology of certain free-living mites (Oribatoidea, Acarina). Batches of fifty adult *Belba*

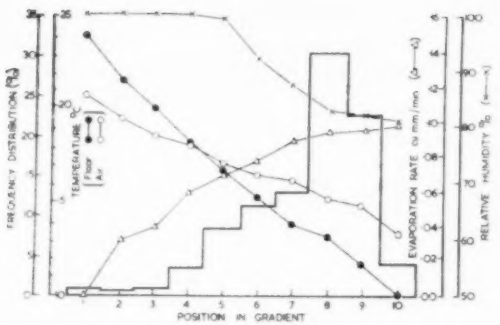

Fig. 1. Distribution of adult *Belba geniculosa* in a temperature gradient in 'saturated' air (mean of three experiments)

geniculosa Ouds., a common oribatid mite of oak-litter, were acclimatized to constant conditions and offered a linear temperature range under 'saturated' conditions. Their positions were recorded at fixed time-intervals to determine where they aggregated.

The apparatus consisted of a copper bar 22 cm. × 4 cm. × 0·2 cm. embedded at each end into insulated copper boxes, which contained heating and cooling agents. The upper side of the metal strip was surrounded by narrow glass sides (1 cm. deep) and covered with a glass plate marked at intervals to facilitate numerical records. The metal strip was covered with moist filter paper and floor and air temperatures within the apparatus were determined at definite intervals by thermistors; evaporation-rates 1 mm. above the floor were measured by a micro-evaporimeter. The relative humidity in the 'cool half' was calculated from aqueous vapour pressures derived from the floor and air temperatures; the atmosphere in the 'warm' half remained completely saturated. Except when recording, the apparatus was kept in darkness.

In Fig. 1 the frequency distribution of adult *B. geniculosa* in a 'saturated' temperature gradient after periods of 3 or 6 hr. is related to the temperature gradient and other physical variables.

By introducing desiccating and humidifying agents into the apparatus, the behaviour of the mites could be recorded under a range of conditions of temperature and humidity. Regardless of changes in relative humidity and evaporating gradients, *B. geniculosa* always aggregated within a floor temperature zone of about 12–14° C. (air temperature 14–16° C.). These results are somewhat surprising for the mites will quickly move towards the region of highest humidity offered to them in a linear relative humidity chamber at constant temperature. Thus temperature seems to have a greater effect than other physical factors and the mites seem to select a zone where death from desiccation will not long be delayed. However, other experiments indicate that desiccation is slow in humidities above 80 per cent, so the situation is more complicated than might be expected.

Temperature is not always the most important factor. Wellington[1,2], for example, found that larvæ of the spruce budworm, *Choristoneura fumiferana* (Clemens), aggregated within certain regions of evaporating gradients independent of temperature and these results were explained in terms of their micro-habitat[3].

Laboratory findings with *B. geniculosa* have been treated somewhat academically in this report and in further work it is hoped to correlate behaviour distributions under controlled conditions with diurnal changes and long-term micro-climatic phenomena in their natural environment.

It is suggested that in future more importance should be attached to all possible physical factors other than temperature in certain types of temperature gradient apparatus. In this way it may be possible to explain some of the existing inconsistencies between field and laboratory observations.

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Mite Orientation and Survival on Flies

PHORESY among arthropods has been widely noted and its importance in population dispersal and survival appreciated. Hypopi, the phoretic stage of mites, have been studied for the most part isolated from their hosts, and little is therefore known of their interaction. We have recently described some behavioural adaptations of the hypopus of *Myianoetus muscarum* (Anoetidae) to fly factors which favour the mite's dispersal[1]. Hypopi are attracted to a volatile substance produced by the pupæ of several fly species, including *Musca domestica*, *Muscina stabulans* and *Stomoxys calcitrans*, and cluster on the anterior end of the pupal case from which the fly is due to emerge. This communication describes the behaviour of the same mite on adult *M. stabulans*.

Hypopi can be found throughout the fly-breeding medium and may cluster on pupæ well down as well as on the surface. Their distribution, however, is mainly on the surface and in large infestations the surface is covered with cinnamon-coloured patches containing thousands of mites. A strip of paper towelling partially inserted into the medium will show a sharp boundary of mites just above the surface—presumably an indication of a preference for moisture. Aggregates of hypopi remain on the pupal case until eclosion, at which time they transfer to the emerging fly. After a brief excursion on the host, the mites occupy characteristic locations for attachment. One of the choice sites is under the dorsal conjunctival folds at the base of the abdomen; another is at the base of setæ. Horizontal rows of mites build outward and toward the rear. In moderate infestations, mites collect on areas bearing setæ and avoid smooth cuticle (Fig. 1). On all areas of the abdomen mites uniformly face toward the rear. This orientation is directly correlated with the pattern of setæ and conjunctival folds which are directed towards the posterior. I have observed hypopi back to the base of an overhanging seta or into a fold in the cuticle, presumably to obtain maximum contact with their anal suckers. This would serve to explain their aversion to smooth cuticle. Mite orientation on the thorax is obscured by its more complex chætotaxy.

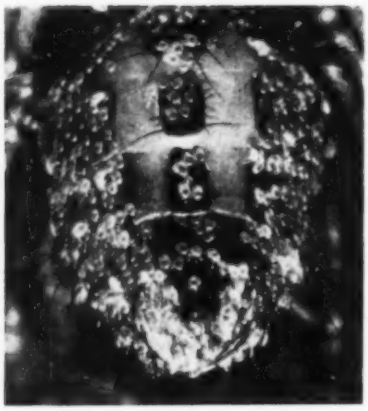

Fig. 1. Ventral abdominal aspect of fly showing preference of mites for areas bearing setæ and their orientation toward the rear

Once settled on the fly, hypopi remain sessile. There is a non-adaptive aspect of this behaviour which is strikingly demonstrated in two ways. The majority of mites will remain attached despite numerous visits of their hosts to a suitable breeding medium. Furthermore, the mites will remain attached to a dead host until they too succumb. Thus, for the majority, phoresy may be a one-way ride. Some of those mites which do transfer to a breeding area remain active for two weeks or longer without moulting. Others soon become quiescent and distended as a result of what appears to be a considerable intake of water. I measured the idiosomal heights of hypopi before and after contact with moisture and found them to be 67μ and 110μ, respectively. The mechanism of water absorption is not known, as the mouthparts are considered to be non-functional. A minimum of two days is required for the appearance of the tritonymph which may moult to the adult stage one day later (at 24° C.).

I have found dessication to be the most crucial factor in mite survival. The following results are based on three replications using about 200 mites in each test. The various stages of the mite were placed in a dry Petri dish at 24° C. and 50 per cent relative humidity. Under these conditions, the feeding stages suffered 100 per cent mortality within 2 hr., while the hypopi completely succumbed after 30 hr. The longevity of hypopi on caged flies kept under the same conditions was a minimum of 47 days. In my experiments the flies died before the mites. It is noteworthy that the microclimate of the fly is most favourable for the survival of hypopi. This is additional evidence of the adaptive value of the phoretic habit.

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MICROBIOLOGY

Action of Mycophenolic Acid on Unstable Diploids of *Penicillium chrysogenum*

Diploids of *Penicillium chrysogenum* heterozygous for the genes *g*/*Y* (yellow versus green conidia) and *w*/*W* (white versus green conidia) have green conidia. On plating, these give rise to a majority of green colonies, together with a small percentage (less than 1 per cent) of yellow or white colonies, or green colonies with white and/or yellow sectors. The proportion of these 'segregant' colonies and sectors is strongly increased (by more than 20–30 per cent) if the conidia are treated with the nitrogen mustard, methyl-*bis*(β-chloroethyl)amine (HN–2) or with X-rays[1]. When certain of the colonies with sectors are sub-cultured by the plating of green conidia, they give rise to a population of colonies with sectors: these colonies maintain the unstable character indefinitely in successive transfers. A dozen unstable clones were isolated, each of which showed sectors with a single phenotype (rarely two) characterized by the presence of nutritional markers as well as by the colour of the conidia. Manganous chloride, added to the agar medium at 40 m*M* concentration, inhibited the production of sectors with nearly all the unstable clones; the inhibition, however, was not of a permanent nature, and disappeared when the clones were subcultured on medium free from manganous chloride[2].

During one experiment, a chance contaminant colony of *Penicillium* sp. was found to grow on a plate of unsupplemented nutrient agar on which colonies of an unstable strain (*D*) produced by treatment with HN–2 were giving rise to yellow sectors. Around the contaminant colony, colonies of strain *D* did not show sectors. The contaminant strain was isolated and cultivated in submerged culture in a corn-steep – dextrin medium, and the filtered broth was sterilized by autoclaving. 1 ml. of broth added to the agar on which strain *D* was plated completely inhibited sectoring of the colonies. As with manganous chloride, when conidia from such colonies were replated on unsupplemented medium, they gave rise again to sectoring colonies.

By extraction with *n*-butyl acetate at acid *p*H, a substance was isolated from the broth which could be easily crystallized from water or from carbon tetrachloride and which reproduced the effect observed with the culture filtrate of the *Penicillium* sp. The chemical and physical properties of this compound agreed closely with those of mycophenolic acid, a well-known metabolite of several *Penicillia*. The identity of the substance was confirmed by comparing its physical, chemical and biological properties with those of a sample of mycophenolic acid kindly supplied by Prof. J. H. Birkinshaw.

Mycophenolic acid inhibits sectoring of strain *D* and other unstable diploid strains of *Penicillium chrysogenum* at a concentration of 1 γgm./ml., that is, at a molar concentration about 10,000 times less than the minimum concentration of manganous chloride required to produce the same effect. The abolition of yellow sectors is not due to a selective effect; yellow colonies derived by plating conidia collected from sectors formed in the absence of mycophenolic acid grew and sporulated normally on agar containing mycophenolic acid. Nevertheless, the formation of yellow sectors from unstable strains is prevented by this substance.

Mycophenolic acid does not show any of the other effects which manganous chloride produces on *Penicillium chrysogenum* treated with mutagens[2], namely, reactivation of viability after treatment with HN-2 and reduction of somatic segregation induced by HN-2 or by X-rays.

The mechanism of genetic instability in diploids of *Penicillium chrysogenum* is still unknown, and therefore the mode of action of mycophenolic acid in this process cannot yet be investigated. The inhibition of the formation of yellow diploid sectors has also been observed with an unstable diploid of *Aspergillus nidulans*; in this strain the yellow sectors were due to a high frequency of somatic crossing-over in chromosome I, probably connected with a breakage-fusion cycle set up in chromosome II (ref. 3).

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The Mycolytic Phenomenon and Biological Control of *Fusarium* in Soil

There have been many attempts to make use of biological control measures for the suppression of plant pathogens, borne by soil. Frequently, these attempts involve the inoculation into soil of organisms which antagonize the pathogens *in vitro*; such procedures try to disturb the natural microbiological equilibrium by the simple introduction into the environment of individual isolates. The frequent failure of the added micro-organisms to become established is not surprising because the biological associations and antagonisms within the ecosystem determine the composition of the microflora, the climax population being a reflexion of the physical and chemical characteristics of the habitat. By modifying the habitat, however, it is possible to alter the composition of the microflora, and such microbiological alterations may destroy plant pathogens borne by soil.

The possibility that mycolytic bacteria, that is, organisms which lyse fungi, are involved in the suppression of certain plant pathogens has been proposed frequently. For example, a lytic factor has been implicated in the control of *Fusarium* by strains of *Achromobacter* and *Pseudomonas*[1] and in the suppression of *Helminthosporium halodes* by *Bacillus subtilis*[2]. In an investigation of the disappearance of *Fusarium oxysporum* f. *cubense* from artificially infested soils, a number of bacteria capable of lysing the fungus were obtained. For the isolation of the mycolytic bacteria, a modification of the method of Mueller and Durrell[3] was used in which living *Fusarium* cells in water agar were included in the enriching medium. The active bacteria grew readily in an inorganic salts medium containing living or dead cells of *F. oxysporum* f. *cubense* as the sole carbon source, but fungus cell-walls isolated by treatment with potassium hydroxide could be substituted for the intact mycelium as the source of carbon. Three of the lytic micro-organisms were identified as strains of *Bacillus cereus*, two others as *Bacillus megaterium*, and a sixth isolate as a strain of *Pseudomonas*. When added to a growing culture of *F. oxysporum*, these bacteria caused a lysis of the fungus. Similar results have been obtained with fungi of several other genera. Furthermore, the bacteria-free culture filtrate of a lytic strain of *Bacillus cereus* grown in a medium containing *F. oxysporum* brought about the lysis of both the living and the dead fungus.

All the mycolytic bacteria exhibited chitinase activity and developed in media containing chitin as the only source of carbon, but culture filtrates prepared from media in which chitinoclastic micro-organisms were grown did not lyse *F. oxysporum*. The latter organisms were obtained from soil by use of chitin-containing enrichment solutions. Similarly, a strain of *Pseudomonas chitinovorans* possessing strong chitinase activity did not lyse the fungus. It would seem, therefore, that chitinase may be implicated in the mycolytic phenomenon, but lysis does not appear to result solely from the activity of this enzyme.

It is possible that mycolysis is a natural means for the biological control of susceptible *Fusaria*. If the active flora could be stimulated selectively in soil, the population of pathogenic fungi might decline. In preliminary work with sterile soil, it was noted that the mycelium of *F. oxysporum* was digested following the addition of a lytic *Bacillus* strain, but, as expected, the addition of mycolytic bacteria to normal soil failed to disturb the microbiological equilibrium to an extent sufficient to result in control of pathogenic *Fusaria*. On the other hand, the fact that all isolates had in common the capacity to utilize chitin suggested that the addition to soil of this polysaccharide might provide a selective means of stimulating the mycolytic population.

To test the possibility for control by such treatments, soil infested artificially with *Fusarium solani* f. *phaseoli* was planted to kidney beans immediately following amendments with chitin, cellulose or ammonium chloride. After six weeks, the severity of root-rotting was determined using a disease index: 0 for no disease and a value of 100 for severe rotting, the final disease index being the mean of all the values for each treatment. The results summarized in Table 1 demonstrate that chitin at a rate of 200 lb. per acre markedly reduced the severity of the root-rotting. Similar results have been obtained with the vascular wilt of radishes caused by *Fusarium oxysporum* f. *conglutinans*. In the radish wilt, chitin reduced the disease index from 47 for infested, untreated soil to a figure of 10 for infested soil treated with 200 lb. chitin. Neither cellulose, another polysaccharide slowly decomposed by the soil microflora, nor inorganic nitrogen produced similar beneficial effects.

Table 1. Effect of Chitin, Cellulose and Ammonium Chloride on the Severity of Rotting of the Bean-Root caused by *Fusarium solani* f. *phaseoli*

Treatment	Disease index (per cent)
None	39
Cellulose, 182 lb./acre	47
Ammonium chloride, 54 lb./acre	43
Cellulose + ammonium chloride	33
Chitin, 200 lb./acre	23
Uninoculated, unamended	0

The influence of chitin may result from an increase in the number of mycolytic micro-organisms. Chitin, however, is known to be one of the few substances which markedly increase the actinomycete population[4]. Because actinomycetes are particularly active in antibiotic production, in culture media at least, the content of antifungal substances in chitin-amended soil was determined by the method described previously[5]. The results obtained indicate that the toxicity of aqueous extracts of chitin-treated soils is far greater than that in unamended controls (K. C. Lu and J. E. Dawson, personal communication). Further work is in progress on the mechanism of the chitin-induced suppression.

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Biological Characteristics of Colicine *X*

The name colicine *X* was given[1] to a colicine produced by the strain of *Escherichia coli* used industrially by Hageda, AG., Berlin-Köln, for the preparation of the emulsion 'Mutaflor'. This colicine can be distinguished from other types of colicines by the following characteristics:

(1) *Specificity of mutants resistant to colicine X.* Specificity to colicines is determined by receptors, which are specific for each colicine[2]. The sensitive bacteria can lose the specific receptors one after another by mutation. By successive mutations a sensitive strain may become resistant towards many colicines. In a series of experiments I used two strains sensitive to colicines *X*, *V*, *B*, *E*, *I*, *K*, S_2+I, *D*, S_1, $J+I$, *A* and *C*, and by successive mutations I was able to isolate 200 mutants resistant to one or more colicines. Loss of receptor for colicine *X* was never accompanied by a loss of receptor for another type of colicine, and cross-resistance between colicine *X* and one of the other 12 colicines was not observed. The experiments prove that mutants resistant to colicine *X* are specific.

(2) *Spectrum of activity.* Colicine *X* is very active against some groups of Enterobacteriaceae; but like the other colicines does not inhibit growth of *Staphylococcus aureus*, *Bacterium anitratum* or *Pseudomonas* (Table 1). The *Escherichia coli*, *Citrobacter* and *Klebsiella-Cloaca* group are more frequently sensitive to colicine *X* than to other colicines, while *Salmonella* and *Proteus* are generally resistant. Strains of *Escherichieae* and *Klebsielleae* isolated from animal faeces are more sensitive to colicine *X* than strains isolated from human faeces; but it is still impossible to explain this ecological difference[3].

Table 1. Activity Spectrum of Colicine *X*

Organism	No. of strains examined	No. of strains sensitive	Percentage
Staphylococcus aureus	30	0	0
Bacterium anitratum	20	0	0
Pseudomonas	27	0	0
Enterobacteriaceae			
Salmonella	40	1	2·5
Proteus	20	0	0
Escherichia coli	130	100	76·9
Citrobacter	16	13	81·2
Klebsiella-Cloaca	40	27	67·5

The sensitivity of *E. coli* isolated from animal faeces towards 13 colicines is reported in Table 2. The results show clearly that colicine *X* is more active against *E. coli* than any other colicine used in this work.

Table 2. Sensitivity of 80 strains of *Escherichia coli* towards Colicine *X* and 12 other Colicines

Type of colicine	No. of sensitive strains	Percentage
X	74	92·5
D	60	75
F	30	37·5
V	29	36·2
B	25	31·2
S_2+I	24	30
E	11	13·7
$J+I$	10	12·5
I	4	5
C	4	5
K	3	3·7
S_1	3	3·7
A	3	3·7

(3) *Other characteristics.* (*a*) The production of colicine *X* is not influenced by growth of the colicinogenic strain in synthetic medium[1].

(*b*) The diameters of the inhibition zones in nutrient agar are usually 20–26 mm. The morphology of the inhibition zone is not characteristic, but resembles that of colicines *D* and *K*.

(*c*) It has been difficult to study the heat resistance of colicine *X*, because suspensions of this colicine with a high titre cannot be prepared by the usual methods [see *d*). Undiluted colicinogenic cultures in broth were used for heat-resistance experiments, and it was found that colicine *X* is destroyed after boiling for 15 min.

(*d*) Colicine *X* is rapidly destroyed by the addition of 2·4 ml. chloroform to 100 ml. of bacterial culture in 'Oxoid' nutrient broth. The strain 'Mutaflor' is sensitive to streptomycin but the addition of streptomycin to the broth culture does not offer any advantages for the preparation of suspensions of colicine, as the concentration of colicine *X* in broth is low. It is possible that colicine *X* does not diffuse easily outside the bacterial cell.

(*e*) Colicine *X* is resistant to the proteolytic enzymes, which are produced by some strains of *Bacilli* or *Proteus*.

The foregoing characteristics permit the distinction of colicine *X* from the other 12 colicines produced by the type cultures of P. Fredericq.

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Athens, 6.

[1] Papavassiliou, J., *Nature*, **184**, 1339 (1959).
[2] Fredericq, P., *Ann. Rev. Microbiol.*, **11**, 7 (1957).
[3] Papavassiliou, J., *Arch. Inst. Pasteur Tunis*, **37**, 103 (1960).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Wednesday, April 5

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London S.W.7), at 5 p.m.—Prof. T. Bergeron (University of Uppsala): "The History of Meteorology" (Evening Discourse).

ROYAL SOCIETY OF MEDICINE, HISTORY OF MEDICINE SECTION (at 1 Wimpole Street, London, W.1), at 5.15 p.m.—Dr. K. D. Keele: "Three Early Masters of Experimental Medicine—Erasistratus, Galen, Leonardo di Vinci" (Presidential Address).

INSTITUTE OF PETROLEUM (at 61 New Cavendish Street, London, W.1), at 5.30 p.m.—Dr. W. Domzalski: "Airborne Techniques in Petroleum Information".

Wednesday, April 5—Friday, April 7

INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY, in collaboration with the INSTITUTION OF ELECTRICAL ENGINEERS (at Brunel College of Technology, Acton, London, W.3)—Symposium on "Electrical Contacts".

Thursday, April 6

INSTITUTE OF REFRIGERATION (at the Institute of Marine Engineers, The Memorial Building, 76 Mark Lane, London, E.C.3), at 5.30 p.m.—Mr. J. A. COX: "Results of Practical Experiments on Relative Humidity Control".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. W. Casson and Mr. H. J. Sheppard: "Technical and Economic Aspects of the Supply of Reactive Power in England and Wales".

BRITISH INSTITUTION OF RADIO ENGINEERS, TELEVISION GROUP (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6 p.m.—Discussion on "Transistorized Television Receivers".

INSTITUTE OF METALS, LONDON LOCAL SECTION (at 17 Belgrave Square, London, S.W.1), at 6 p.m.—Annual General Meeting, followed by Mr. K. M. Bills: "Physical Methods of Analysis for Major Alloying Constituents".

SOCIETY FOR ANALYTICAL CHEMISTRY, BIOLOGICAL METHODS GROUP (at "The Feathers", Tudor Street, London, E.C.4), at 6.30 p.m.—Discussion Meeting on "Principles Involved in Collaborative Studies" opened by Mr. S. A. Price.

Friday, April 7

INSTITUTION OF ELECTRICAL ENGINEERS, MEDICAL ELECTRONICS DISCUSSION GROUP (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "The Conversion of Biological Data into Electrical Signals".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN MATHEMATICS—The Principal, Nottingham Training College, Clifton, Nottingham (April 10).

DEMONSTRATOR IN CHEMISTRY—The Registrar, University College of North Staffordshire, Keele, Staffs (April 14).

ASSISTANT IN THE DEPARTMENT OF ZOOLOGY—The Secretary, The University, Edinburgh (April 15).

ASSISTANT LECTURER IN INORGANIC CHEMISTRY—The Registrar, The University, Manchester 13 (April 15).

LECTURER (suitably qualified science graduate) IN BACTERIOLOGICAL BIOCHEMISTRY—The Registrar and Secretary, King's College (University of Durham), Newcastle upon Tyne (April 15).

LECTURER (with medical qualifications) IN ANATOMY—The Secretary, Medical College of St. Bartholomew's Hospital, West Smithfield, London, E.C.1 (April 15).

UNIVERSITY DEMONSTRATOR IN BOTANY, with special reference to cytology and genetics—Dr. C. B. Goodhart, Museum of Zoology, The University, Downing Street, Cambridge (April 17).

LECTURER (suitably qualified graduate with experience or interest in the problems of agricultural research) IN STATISTICS—The Secretary, Wye College (University of London), near Ashford, Kent (April 21).

ASSISTANT LECTURER, Grade B (preferably with a university degree or equivalent qualifications) IN THE DEPARTMENT OF SCIENCE AND METALLURGY, to teach physics and mathematics mainly to Ordinary National Certificate classes—The Principal, North Lindsey Technical College, Kingsway, Scunthorpe, Lincs (April 22).

SENIOR LECTURER or LECTURER IN VETERINARY ANATOMY; a SENIOR LECTURER or LECTURER IN VETERINARY HISTOLOGY; a SENIOR LECTURER or LECTURER IN VETERINARY MEDICINE; and a SENIOR LECTURER or LECTURER IN VETERINARY PHARMACOLOGY at the University of Khartoum—The Registrar, University of Khartoum, c/o Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 22).

LECTURER IN ELECTRICAL ENGINEERING; and a LECTURER IN MECHANICAL ENGINEERING—The Registrar, Trinity College, Dublin (April 24).

LECTURER or ASSISTANT LECTURER IN PHILOSOPHY—The Registrar, The University, Hull (April 24).

READER or LECTURER IN THE PHILOSOPHY OF MATHEMATICS—The Secretary of Faculties, University Registry, Oxford (April 24).

RESEARCH FELLOW (with a Ph.D. degree or equivalent experience) IN THE CHEMISTRY DEPARTMENT, for fundamental work on compounds of potential use in the paint industry—The Professor of Chemistry, The University, Hull (April 24).

ASSISTANT LECTURER (preferably with an interest in theoretical or experimental plasma physics) IN PHYSICS—The Secretary, The Queen's University, Belfast (April 29).

LECTURER IN APPLIED MATHEMATICS—The Principal, Jesus College, Oxford (May 1).

LECTURER IN HISTOLOGY AND EMBRYOLOGY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, May 5).

RESEARCH DEMONSTRATOR (graduate in botany), to engage in research, preferably in plant physiology and biochemistry, plant pathology and ecology; and a RESEARCH ASSISTANT (graduate in botany or graduating this year), to assist the Professor in the establishment and maintenance of a collection of plant organ and tissue cultures and in research involving these cultures—The Registrar, University College, Singleton Park, Swansea (May 13).

CHAIR OF MATHEMATICS (R.A.A.F. Academy), University of Melbourne—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, May 15).

ASSISTANT LECTURERS (with appropriate qualifications and teaching and research experience) IN APPLIED OR PURE MATHEMATICS at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong and London, May 19).

LECTURER (preferably with the ability to offer courses in methods of teaching chemistry and/or biology) IN EDUCATION at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong and London, May 19).

LECTURER (with an honours degree in zoology and preferably some experience of teaching and research) IN ZOOLOGY at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong and London, May 30).

BACTERIOLOGIST (graduate in science or veterinary science) at the Animal Health Trust Farm Livestock Research Centre, Stock, Essex, to assist in a programme of research into enteric diseases of young farm animals, with special reference to pigs—The Scientific Director, Animal Health Trust, 14 Ashley Place, London, S.W.1.

GLASSBLOWER—Dr. J. K. N. Jones, Chemistry Department, Queen's University, Kingston, Ontario, Canada.

HEAD OF THE DEPARTMENT OF SCIENCE AND ELECTRICAL ENGINEERING—The Principal, College of Technology, Broadway, Letchworth, Herts.

LABORATORY TECHNICIAN (Grade III) IN THE DEPARTMENT OF PHYSIOLOGICAL CHEMISTRY, to assist with classes in practical physiology and some experimental work—The Assistant Bursar, The University, Reading.

POSTDOCTORAL FELLOW IN THE DEPARTMENT OF CHEMICAL ENGINEERING, for research in flame spectroscopy or a related subject—Dr. A. G. Gaydon, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7.

RESEARCH ASSISTANT (preferably with a good chemical background) IN THE DEPARTMENT OF CHEMICAL ENGINEERING, for work on the fractionation and analysis of lipoprotein extracts—The Secretary, University College London, Gower Street, London, W.C.1.

RESEARCH FELLOW IN THE DEPARTMENT OF ELECTRICAL ENGINEERING, for work on instrumentation and telemetering for physiological measurement on athletes—The Academic Registrar, Loughborough College of Technology, Loughborough, Leicestershire, quoting Ref. 20/AF/2.

RESEARCH FELLOWS (2) (preferably with a Ph.D. degree in engineering or physics, or equivalent research experience) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING under Prof. A. L. Cullen, for research in the field of millimetre wave techniques—The Registrar, The University, Sheffield 10.

SCIENTIFIC OFFICER, SENIOR SCIENTIFIC OFFICER or PRINCIPAL SCIENTIFIC OFFICER (preferably with experience in tissue culture techniques), for research work in virus diseases—The Secretary, Animal Diseases Research Association, Moredun Institute, Gilmerton, Edinburgh 9.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

The Nuffield Foundation—Report for the year ended 30 March 1960. Pp. xiii + 144. (London: The Nuffield Foundation, 1960.) [3012

Department of Scientific and Industrial Research. A Survey of Nickel and Chromium Recovery in the Electroplating Industry. By E. F. Harris. Pp. iv + 44. (London: Department of Scientific and Industrial Research, 1960.) [3012

London and Home Counties Regional Advisory Council for Technological Education. Bulletin of Special Courses in Higher Technology, including Management Studies and Commerce, 1960-61. Part 2: Spring and Summer Terms. Pp. 78. (London: London and Home Counties Regional Advisory Council for Technological Education, 1960.) 3*s.* 6*d.* [3012

Labelling Procedure for Compounded Medicinal Preparations. (A memorandum issued by the Association of British Pharmaceutical Industry, the Proprietary Association of Great Britain; and the Association of Public Analysts.) Pp. 6. (London: Association of British Pharmaceutical Industry, 1960.) [3012

Ciba (A.R.L.), Ltd. Technical Notes, No. 216 (December, 1960): Bonded Helicopter Blades. Pp. 6. (Duxford: Ciba (A.R.L.), Ltd., 1960.) [3012

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Glasshouse Crops Research Institute. Annual Report, 1959. Pp. 141 + 6 plates. (Rustington, Littlehampton: Glasshouse Crops Research Institute, 1960.) 10s. [3012

Colonial Office. Colonial Research, 1959-1960: Reports of the Committee for Colonial Agricultural, Animal Health and Forestry Research; Colonial Economic Research Committee; Colonial Fisheries Advisory Committee; Colonial Medical Research Committee; Colonial Pesticides Research Committee; Colonial Road Research Committee; Colonial Social Science Research Council; Tsetse Fly and Trypanosomiasis Committee; Director, Anti-Locust Research Centre; and Research Matters not covered by the above Reports of the Specialist Advisory Bodies. Pp. 381. (Cmnd. 1215). (London: H.M. Stationery Office, 1960.) 17s. net. [3012

Better Opportunities in Technical Education. Pp. 24. (Cmnd. 1254.) (London: H.M. Stationery Office, 1961.) 1s. 3d. net. [101

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Home Office. Delinquent Generations: a Home Office Research Unit Report. By Leslie T. Wilkins. (Studies in the Causes of Delinquency and the Treatment of Offenders, No. 3.) Pp. iv + 19. (London: H.M. Stationery Office, 1960.) 1s. 6d. net. [101

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Supplement to "British Chemicals and their Manufacturers". (The Directory of the Association of British Chemical Manufacturers.) Pp. 35. (London: Association of British Chemical Manufacturers, 1960.) [101

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Department of Scientific and Industrial Research: Building Research Station. Factory Building Studies No. 9: Fire Protection in Factory Buildings. Pp. iv + 28. (London: H.M. Stationery Office, 1960.) 3s. 6d. net. [111

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Other Countries

Egyptian Reviews of Science, Vol. 3: Review of Fungal Disease of Cotton in Egypt. By Dr. M. A. Mostafa. Pp. 55. (Cairo: The Science Council, 1960.) [3012

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Ministerio de Agricultura, Bogota, D. E.—Colombia, Division de Investigaciones Agropecuarias, D.I.A. Boletin Tecnico No. 5: Fertilizacion de la Papa en Antioquia. Por Manuel Rodriguez J., B. Baird y Jairo Correa V. Pp. 22. Boletin Tecnico No. 6: Fertilizacion de la Papa en la Sabana de Bogota y Alfrededores. Por Victor M. Vega-J., Genaro Diaz-R. y Guy B. Baird. Pp. 31. (Bogota: Ministerio de Agricultura, 1960.) [3012

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Transatom Bulletin, Vol. 1, No. 4 (December, 1960). (Information on Translations covering Nuclear Literature.) Pp. 80. Published monthly. Annual subscription: Ordinary Mail, 400 Belgian francs (8 U.S. dollars). Air Mail (for non-European countries) 800 Belgian francs (16 U.S. dollars). Single copies 50 Belgian francs (1 U.S. dollar). (Bruxelles: Euratom, Transatom Service, 51 rue Belliard, 1960.) [111

International Atomic Energy Agency, Vienna. Assistance through Fellowship and Exchange Programmes in Nuclear Science—Information—Opportunities—Procedures. Pp. 37. (Vienna: International Atomic Energy Agency, 1960.) [111

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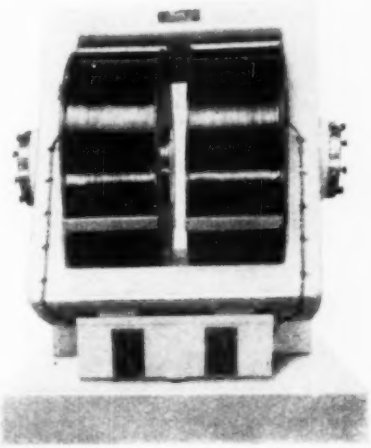

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A. UNDERWATER WEAPONS ESTABLISHMENT, PORTLAND, DORSET (Ref. C69/1A)

(1) Mechanical Engineer. Specialized in thermodynamics with experience in internal combustion engine research and/or rocket propulsion field. Minimum five years' experience in either expected. Some experience in appropriate instrumentation essential with design study work on components of rocket systems or other propulsion gear. Turbine design experience advantageous.

(2) Mechanical Engineer with bias for one or more of: (i) hydraulically operated mechanisms, including servo-control; (ii) mechanics of machines (theory and practice); (iii) hydro- (or aero-) dynamics of fairly elementary character.

(3) Hydrodynamicist (or aeronautical engineer), with some years' experience for work on torpedo dynamics.

(4) Mechanical Engineers (servo-mechanisms, gyro design and develop). Electrical Engineers (Electronics/Design). Mathematicians (Operational research and theoretical physics). Physicist (acoustics).

B. GOVERNMENT COMMUNICATIONS H.Q., CHELTENHAM (Ref. A43/1A)

Physicists (Telecommunications). Mathematicians. Electrical Engineers (Electronics/Radar: Telecommunications and Radio).

C. NAVAL CONSTRUCTION RESEARCH ESTABLISHMENT, DUNFERMLINE (Ref. C70/1A)

Structural and Mechanical Engineers, Mathematical Physicists and Mathematicians, for teams engaged on research problems of structural strength, effects of conventional and nuclear weapons and development of new structural materials. Excellent opportunities and good prospects for promotion.

D. ADMIRALTY COMPASS OBSERVATORY, SLOUGH (Ref. D47/1A)

Electrical or Mechanical Engineers or Physicists interested in gyro-techniques, servo-mechanisms or electronics.

Qualifications for all posts first- or second-class honours degree or equivalent in appropriate subject. Must normally be natural born British subjects of natural born British parents. Senior Scientific Officers must have had minimum three years' postgraduate experience and be not less than 26 years of age.

Salaries: (A.) Senior Scientific Officer, £1,302 to £1,604; Scientific Officer, £717 to £1,186. (B, C, D.) Senior Scientific Officer, £1,342 to £1,654; Scientific Officer, £738 to £1,222.

Appointments unestablished (with F.S.S.U. benefits) but opportunities for those between 21 and 32 to compete for established posts.

Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting appropriate reference and post.

OLDCHURCH HOSPITAL ROMFORD, ESSEX

(709 Beds)

RADIOTHERAPY DEPARTMENT

Senior Technician or Technician required for the above Department. Duties include Physics Workshop, Isotope Laboratory, Radium and Mould Room work. Instrument or Physics Workshop experience essential. Salary £570 to £710 per annum; senior grade, £710 to £905 per annum would be applicable to suitably qualified person.

Applications, quoting Ref. 17/39, giving full details, including age and experience, together with names of two referees and/or copy of testimonials to the Group Secretary, Romford H.M.C., Oldchurch Road, Romford.

NOTTINGHAM NO. 2 HOSPITAL MANAGEMENT COMMITTEE

Applications are invited from persons holding an appropriate science degree, or the A.R.I.C., for the appointment of Senior Biochemist within the Nottingham No. 2 Group of Hospitals. The person appointed will work under the direction of the Chemical Pathologist at the City Hospital where there is a fully equipped biochemical laboratory. Salary scale £1,250 to £1,700 per annum.

Applications, stating age, experience and qualifications, with the names and addresses of two referees, should be sent to the undersigned as soon as possible.

J. H. HARGREAVES,
Group Secretary.

Sherwood Hospital, Nottingham.

AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

SOIL SCIENTIST

The Organization's **Division of Land Research and Regional Survey, Canberra, A.C.T.,** invites applications for the position of Soil Scientist from honours graduates in Science or Agricultural Science with research and field experience in soil survey. Training in plant ecology and geomorphology desirable. The work involves extensive use of aerial photographs and their interpretation.

The appointee will participate as a member of the Division's scientific unit which for fourteen years has been conducting potentiality surveys on the Australian Mainland and in Papua and New Guinea. Studies in geology, geomorphology, pedology, botany and climatology of the region are co-ordinated and the appointee will be expected to contribute to composite reports and publish individual specialist papers. Initially the appointee will join the unit working on the Mainland for three to four months in at least alternate years and the rest of the time at Headquarters in Canberra engaged on the compilation of maps, reports and preparation of papers.

SALARY: Dependent on qualifications and experience within the ranges: £A.1,510 to £A.2,265 per annum or £A.2,395 to £A.2,720 per annum.

Promotion within C.S.I.R.O. is by merit and may ultimately go beyond the upper limit of the scale within which the original appointment is made.

Fares paid. Further information on this and other conditions supplied on application to:

Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2.

to whom applications (quoting Appointment No.: 570/92) should be addressed by May 15, 1961.

RHODESIAN SELECTION TRUST GROUP OF COMPANIES

SOIL PHYSICIST

The Kafue Pilot Polder Trust in NORTHERN RHODESIA require the services of a Soil Physicist with training in modern techniques and preferably with experience of irrigation of heavy clays. The soils of the Polder are uncommon and present considerable opportunities for new and original research.

A commencing salary of not less than £2,500 per annum is envisaged, together with liberal fringe benefits.

Applications with curricula vitae should be forwarded to the address below. Applicants should quote the names and addresses of three referees, and also state a possible date of commencement.

Personnel Officer,
Vainona Estates Limited,
c/o Rhodesian Selection Trust Limited,
P.O. Box 1479,
SALISBURY,
Southern Rhodesia.

THE INTERNATIONAL NICKEL COMPANY (MOND) LTD.

requires

ASSISTANT IN TECHNICAL INFORMATION SECTION

The activities of the Section cover literature searching, abstracting, translating, indexing, and handling of inquiries. Applicants should possess a good degree or equivalent (natural sciences or technology preferred). Knowledge of Russian is essential and additional languages would be advantageous. Age should not exceed 35.

Pension and assurance schemes are in operation and, in appropriate cases, assistance can be given with housing.

Apply, giving full particulars of qualifications, experience, age, salary required, etc., to:

The General Manager, Development and Research Department, The International Nickel Company (Mond) Ltd., Thames House, Millbank, London, S.W.1.

Mark envelope "Confidential, M.11.N."

ICI

PHARMACEUTICAL RESEARCH

A vacancy exists in the Pharmaceutical Research Laboratories, at Alderley Park, for a

YOUNG GRADUATE

(male or female) preferably with a knowledge of mammalian histology, for work in connection with toxicological investigations on synthetic drugs. Training will be given in Histopathology.

The Laboratories are amongst the most up-to-date and best equipped in the world, situated between Wilmslow and Macclesfield in pleasant though not isolated rural surroundings.

Applications, with brief particulars, should be addressed to the:

Division Staff Manager
Imperial Chemical Industries Limited
Pharmaceuticals Division, Fulshaw Hall
Wilmslow, Cheshire

CYANAMID INTERNATIONAL

WANTED: by a large international company specialising in animal nutrition and animal health products.

AGRICULTURAL SCIENTIFIC CO-ORDINATOR FOR EUROPE

to co-ordinate research development and technical services in Western Europe.

Applicants should have a veterinary qualification and at least ten years' experience in animal husbandry with an interest in current problems of animal nutrition, with a good academic training. The possession of a higher degree, a knowledge of German and some commercial experience are essential. The appointment will be based in London.

Salary commensurate with the duties of such an appointment and not less than £2,500 per annum, with travelling expenses. The Company operates a contributory Pension and Life Assurance Scheme.

Applications should be sent to Dr. W. M. McKay, M.R.C.V.S., Regional Co-ordinator for Western Europe, Cyanamid International. London address: Bush House, Aldwych, London, W.C.2.

UNIVERSITY COLLEGE
IBADAN, NIGERIA

Applications are invited for Research Fellow in Department of Chemistry to join a group working on the Chemistry of the West African Flora, in particular to investigate the bitter principles of the West African Cucurbitaceae. Candidates must have minimum of three years' postgraduate research experience. Salary scales: £1,200 by £75 to £1,650 (bar); £1,725 by £75 to £2,175 per annum. Passages paid for appointee, wife and up to five children under 11 years, on appointment, annual overseas leave and termination. Children's, car and outfit allowances. F.S.S.U. Part-furnished accommodation at rent not exceeding 7.7 per cent of salary.

Detailed applications (six copies), naming three referees, by May 1, 1961, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

DEPUTY CHIEF ANALYST. QUALIFIED chemists are invited to apply for this appointment in new City of London Research Laboratories. The work is varied but mainly concerned with food products. Experience in a Public Analyst Laboratory an advantage.—Write, stating age, qualifications and experience, to Box 961, T. G. Scott and Son, Ltd., 1 Clement's Inn, London, W.C.2.

UNIVERSITY OF READING. RESEARCH Demonstrators (two) in Department of Horticulture, to assist with practical classes on vegetable crops and ornamental plants respectively. The successful candidates will be able to apply to register for a higher degree and carry out research, preferably on developmental physiology of a vegetable crop or ornamental plant. Good degree in horticulture or botany essential.—Apply Professor O. V. S. Heath, F.R.S., University of Reading Horticultural Research Laboratories, Shinfield Grange, Shinfield, Berks.

NEW ZEALAND
FORESTRY DEPARTMENT

Applications are invited for the undermentioned vacancy:

Vacancy No. 766. Assistant Mycologist, Forest Research Institute, Rotorua, N.Z. Forest Service. Salary: Up to £1,165 with maximum at any point. Appointee with suitable experience and qualifications will be graded on the Scientific Officers scale which provides for advancement up to £2,150 a year for outstanding officers. Qualifications desired: M.Sc. or B.Sc. degree in botany, forestry or agriculture. Duties: Investigation of fungi associated with forest trees and/or fungal toxonomy. Applicants should preferably be male as the position involves periods of field work in difficult country. Passages: Steamer fares of up to £165 each for the appointee and his wife, and pro rata for dependent children will be paid. Incidental expenses: Up to £35 for a single person and £100 for a married man can be claimed to cover the cost of taking personal effects to New Zealand.

Application forms and further details are available from the High Commissioner for New Zealand, 415 Strand, London, W.C.2, with whom applications will close on April 29, 1961. Please quote reference B13/8/1 when inquiring.

ABSTRACTOR

The Reed Paper Group has a vacancy for an Abstractor in one of the Group's Development Departments.

Candidates, of either sex, should have had previous experience of abstracting and have the ability to grasp quickly the essence of a paper. They should be able to write fluently, in a clear, concise style. Knowledge of related work, e.g., preparation of literature reviews, is also desirable.

Applicants should preferably be graduates, or have an adequate technical background.

Excellent conditions of service include assistance with house purchase and non-contributory pension fund. The appointment will be tenable at Aylesford, Kent.

Written applications, with details of age, experience and present salary should be addressed to:

The Group Personnel Officer,
Albert E. Reed and Co. Ltd.,
Larkfield, near Maidstone, Kent.
quoting reference A/PBDL/75.

MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY
(FACULTY OF TECHNOLOGY IN THE UNIVERSITY OF MANCHESTER)

The Governing Body invites applications for three Lectureships in Mechanical Engineering in the College, corresponding title and status in the University of Manchester. Candidates should have a major interest in Production Processes, particularly Design Metal Cutting, Metal Forming or Automatic Control, or in Thermodynamics or Fluid Mechanics. The successful candidates will be required to assist in the development and teaching of Courses on these topics and to undertake research for higher degrees. Salary, according to qualifications and experience, in the scale £1,050 by £50 to £1,400 by £75 to £1,850 per annum. F.S.S.U. and family allowances.

Conditions of appointment and form of application may be obtained from the Registrar, The Manchester College of Science and Technology, Manchester, 1. The last day for the receipt of applications is Saturday, April 15, 1961.

STOKE MANDEVILLE HOSPITAL
AYLESBURY

Assistant Biochemist required in the Area Pathology Laboratory based at the above Hospital. Applicants should possess first- or second-class honours degree in chemistry or biochemistry, or A.R.I.C. Whitley Council conditions of service. Salary £925 to £1,150 per annum after (for new entrants only) a probationary period. The post offers a wide variety of experience in a well-equipped and pleasant laboratory.

Applications, giving full details of qualifications, etc., together with names of two referees, to be forwarded to the Administrative Officer as soon as possible.

BRISTOL SIDDELEY ENGINES

RESEARCH PHYSICISTS and ENGINEERS

Bristol Siddeley Engines Limited require qualified men to work on problems of air-breathing propulsion at very high speeds, in the following fields:—

Properties of gases at very high temperatures.
Combustion in supersonic gas streams.
Heat transfer at supersonic relative velocity.

For this work new test facilities are now coming into operation as part of the Company's planned expansion in this field.

Applicants should have had some relevant research experience. These are senior appointments and the salaries will match the high standards required.

If you would like to visit Bristol to discuss your participation in this work, please write, quoting reference 25/61, to:—**H. J. Thompson, Personnel Manager, Bristol Siddeley Engines Limited, PO Box 3, Filton, Bristol.**

MSL

have been retained to advise on the appointment of

RESEARCH AND DEVELOPMENT DIRECTOR

FOOD

for a British group of companies which has its parent organization in U.S.A. This is a new post and will be based in the outer London area with responsibility to the British Chairman for planning and directing the group's research and development programme, and the overall direction of quality standards and manufacturing processes. Salary will be in the £2,500 to £3,500 bracket with contributory pension scheme.

Candidates, 35 to 45, must have a science degree and at least five years' industrial research experience including food technology, with managerial status. Please send brief details in confidence, quoting reference U.3220, to H. C. S. Brand.

MANAGEMENT SELECTION LIMITED
17 Stratton Street, London, W.1

In no circumstances will a candidate's identity be disclosed to our client unless he gives permission after a confidential interview at which he will be given full details of the appointment.

SENIOR INVESTIGATOR IN TROPICAL ANIMAL ECOLOGY

The Committee of the Nuffield Unit of Tropical Animal Ecology intend to appoint a Senior Investigator to undertake research on a tropical environment considered primarily as a habitat of large mammals. Appointment will be for five years and will have effect from October 1, 1961, or as soon thereafter as it is practicable for the person appointed to enter upon his duties. The appointment of a Junior Investigator is expected to follow in the course of the first year. The Senior Investigator will normally be stationed at Mweya in the Queen Elizabeth National Park, Uganda, where living accommodation will be provided; but he will be expected to spend two periods of not less than six months each working at the Zoological Laboratory, Cambridge. The Council of Makerere College has agreed that the Senior Investigator may be appointed as Honorary Lecturer in the Department of Zoology, Makerere College. The pensionable stipend will be within the scale of £1,250 a year rising by annual increments of £50 to £1,400 and thereafter by £75 to £1,850 a year. The Committee may give a number of years' seniority for the purpose of determining the stipend. In addition there will be, where applicable, a non-pensionable overseas allowance not exceeding £300 a year. The necessary passages of the person appointed and his wife between Uganda and the United Kingdom will be paid; and a non-pensionable allowance of £50 will be paid for each dependent child who is under the age of sixteen. Leave will be granted at the rate of six weeks a year.

Further information can be obtained from the Secretary of the Nuffield Unit, Department of Zoology, Downing Street, Cambridge. Candidates should send their applications, with the names and addresses of three persons to whom reference can be made, and with any supporting evidence they wish to submit, to the Secretary so as to reach him not later than May 20, 1961.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

PHYSICS DEPARTMENT

Applications are invited for the following posts in the photoelectronics section:

Lecturer. Salary in range £1,050 by £50 to £1,400 by £75 to £1,550 (bar) by £75 to £1,850 per annum, plus £60 per annum London Allowance and Family Allowance of £50 per child per annum. F.S.S.U. membership. Duties include teaching general physics and special advanced course, research in application of photoelectronics to nuclear physics, astronomy, space research, etc.

Research Assistant (Academic) to assist in research in the fields of vacuum physics and photoelectronics. A good degree essential and some research experience preferable. Salary in range £700 to £1,100 per annum depending upon qualifications, plus family allowance. F.S.S.U. membership.

Apply, with full personal and academic details and names of two referees, to Professor J. D. McGee, Physics Department, Imperial College of Science and Technology, London, S.W.7.

BRADFORD INSTITUTE OF TECHNOLOGY

DEPARTMENT OF CHEMICAL TECHNOLOGY

Applications are invited for the post of Lecturer in Physical Chemistry with special knowledge and/or experience in Spectrophotometry and Colorimetry. Salary scale in accordance with the Burnham Technical Award, namely, £1,370 to £1,550 per annum. Previous industrial or research experience at a suitable level may be taken into account in fixing the commencing salary.

Further particulars and forms of application may be obtained from the Registrar (Department F), Bradford Institute of Technology, Bradford 7.

HENRY PATTEN,
Clerk to the Governors.

APPLICATIONS ARE INVITED FROM A physicist or physical chemist to undertake research in connection with problems in food manufacture. Initial duties will be concerned with investigations into the rate of diffusion of moisture during the drying of confectionery and the person appointed will be expected to develop experimental techniques appropriate to the study. The candidate must hold a university degree and should have some experience in the conduct of research.—Apply in writing to the Director of Research, British Food Manufacturing Industries Research Association, Randalls Road, Leatherhead, Surrey, giving details of qualifications and salary expected. The post carries comparable pension and life insurance rights. Applications should be marked "Private and Confidential."

UNIVERSITY OF LIVERPOOL

Applications are invited for the following posts in the School of Dental Surgery: (a) Assistant Lecturer or Lecturer in Dental Biochemistry at an initial salary within the range £800 to £1,475 per annum, according to age, qualifications and experience of the successful candidate. Applications stating age, qualifications and experience together with the names of three referees, should be received not later than April 30, 1961, by the Registrar, from whom further particulars may be obtained. Quoting reference CV/N. (b) Research Assistant in Dental Biochemistry to pursue investigations into the metabolism of bone and teeth. The appointment will commence in September, 1961, and will be for one year in the first instance, but renewable for a maximum period of two further years. The holder of the appointment will have the opportunity to read for a higher degree. Applicants should hold a good honours degree in biochemistry. The salary for the first year will be £500.

Applications, stating age, nationality, qualifications and experience, together with the names of two referees, should be received by the Registrar not later than June 30, 1961. Quoting reference CV/N.

GRADUATE CHEMIST AND SENIOR TECHNICIAN

A New Zealand company engaged in chemical industry has positions available for suitable persons who have either graduated in Chemistry or who have had experience as a technician in an industrial chemical laboratory. Selected applicants would receive assistance in emigrating to New Zealand and would be bound to serve with the company for a minimum period of two years.

Bona fide inquiries should be sent in the first instance by airmail to the Works Director, Ivon Watkins Limited, P.O. Box 144, New Plymouth, New Zealand. Following receipt of such inquiries, which should include as much information as possible giving age, marital status, qualifications and experience and accompanied by *copies only* of testimonials, arrangements will be made for interview in the United Kingdom (preferably in May) when the Managing Director will be visiting England. Inquirers will be advised of time and place of interview.

Ivon Watkins Limited is a New Zealand company actively engaged in the development of chemical industry and offers unique opportunities to graduates and technicians with some experience in chemical industry.

QUEENSLAND INSTITUTE OF MEDICAL RESEARCH

BRISBANE, AUSTRALIA

Applications are invited for the position of Director of the above Institute. The duties are (1) to direct research work and control research staff of the Institute, (2) to continue to develop the Institute on a comprehensive research basis, and (3) to plan the permanent housing of Institute. To date, research has been almost entirely in the field of communicable disease. The salary is £A.4,583 per annum. Tenure is for seven years, with eligibility for reappointment. Technical and lay staff, other than term appointees, such as the Director, are subject to the Public Service Acts, and administration generally follows Public Service practice. Appointee will be required to commence duty as early as possible after August 1, 1961.

Applications close, on April 30, 1961, with Agent-General for Queensland, 409 and 410 Strand, London, W.C.2, from whom intending applicants should obtain application forms and further information.

U.S.A.

UNIVERSITY OF ALABAMA MEDICAL SCHOOL

GENERAL BIOCHEMIST

Biochemist required for Gastroenterology Research Laboratories with special interest in gastric secretion (electrolytes, pepsin), small bowel absorption and lipid analysis. Research experience essential. Starting salary according to experience, but would not be less than $7,000 per annum.

MEDICAL TECHNICIAN

Medical Technician required for Gastroenterology Research Laboratories with special interest in gastric secretion (electrolytes, pepsin), small bowel absorption and lipid analysis. Research experience desirable but not essential.

Applications should be addressed to:
Basil I. Hirschowitz, M.D.,
Director, Division of Gastroenterology,
University of Alabama Medical Center,
Birmingham, Alabama.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

Applications are invited for a Lectureship in Mineral Technology. Salary in range £1,050 to £1,850 per annum, according to qualifications, plus £60 per annum London allowance, family allowances and F.S.S.U. membership. The successful candidate will be required to organize and take charge of a course on the chemical and engineering principles of liquid-solid and gas-solid processes for the treatment of ores and minerals, including leaching, drying and roasting. He should also be qualified to conduct and supervise research in this field.

Applications, with full details of qualifications and experience, to Dr. M. G. Fleming, Imperial College of Science and Technology, London, S.W.7.

THE DISTILLERS COMPANY LIMITED

EMULSION PAINT TECHNOLOGIST

British Resin Products Limited, a subsidiary of The Distillers Company Limited, wish to appoint an Emulsion Paint Technologist in the Technical Service Laboratories at their factory in Barry, Glamorgan.

Candidates must have had a number of years experience in the formulation and evaluation of emulsion paints.

The successful candidate will lead a section responsible for giving technical service to paint customers and also for the assessment of new materials, and the development of outlets for them.

Write:
STAFF MANAGER
THE DISTILLERS COMPANY LIMITED
21/22 BOLTON STREET
LONDON, W.1.

Quote Ref. 17/61.N.

JOHN INNES INSTITUTE

Applications are invited from biochemists, biophysicists and physical chemists with an interest in biological problems for positions on the staff of the new Cell Biology Department at the John Innes Institute. The work of the laboratory is broadly based on problems in the physiology and biochemistry of animal and plant cells. Current investigations include studies on the biology and chemistry of nucleic acids, on nucleo-cytoplasmic interrelationships and on factors controlling cell multiplications. The appointments are at various levels and will interest both established investigators and those who might profit by a period of collaboration with senior workers.

Inquiries should be addressed to the Head of the Department of Cell Biology, John Innes Institute, Bayfordbury, Hertford, Herts, from whom further information may be obtained.

INSTITUTE OF OPHTHALMOLOGY

(UNIVERSITY OF LONDON)
JUDD STREET, LONDON, W.C.1

A vacancy exists for a Technician in Research Department. Previous experience of histological techniques an advantage. Salary according to recognized scales.

Further particulars from and applications in writing, with names of two referees, to Secretary at above address.

UNIVERSITY OF ABERDEEN. APPLICATIONS are invited from suitably qualified persons to operate (and maintain) an electron microscope to be installed shortly for scientific and medical departments within the University. Experience of operation and maintenance of an electron microscope essential and knowledge of electronics and high vacuum technique an advantage. Salary on scale £690 to £815 per annum, plus appropriate supplementation for qualifications.—Applications, with names of two referees, to Secretary to the University, Marischal College, Aberdeen, by April 10, 1961.

LINCOLNSHIRE RADIOTHERAPY CENTRE

PHYSICS LABORATORY

Applications are invited for the post of Isotope Laboratory Technician in the Lincolnshire Radiotherapy Centre now being set up at St. George's Hospital, Lincoln. The work involved is the use of various types of Isotopes both on patients for diagnostic studies and Therapeutic treatment and also experimental studies. Candidates should have a good school record with passes in physics and mathematics at "O" or Advanced Level of the G.C.E., or O.N.C. in applied physics or Inter.B.Sc. or equivalent qualifications. Salary scale at age 21, £570 to £710 per annum.

Applications, giving details of education, qualifications and experience, together with the names of two referees, should be addressed to the Group Secretary, Lincoln No. 1 Hospital Management Committee, County Hospital, Lincoln, from whom further particulars can be obtained.

PETERBOROUGH JOINT EDUCATION BOARD

PETERBOROUGH TECHNICAL COLLEGE

Applications are invited for the following full-time appointments for September 1, 1961: 1 Grade B Assistant to teach Biology to G.C.E. Advanced Level and to Pre-nursing Classes with some General Science. 2 Grade B Assistant to teach Physics to G.C.E. Advanced Level and to O.N.C. classes. For these posts either teacher training or teaching experience is an additional recommendation. Salaries in accordance with Burnham Technical Scales with allowances for degree and approved industrial/commercial experience; £700 minimum rising to £1,150 per annum.

Further particulars and forms of application may be obtained from the Principal, Peterborough Technical College, Easterfield Road, Peterborough, to whom applications should be returned within fourteen days.

SOUTH-EAST ESSEX TECHNICAL COLLEGE

LONGBRIDGE ROAD, DAGENHAM

Required September: Assistant Lecturer (Grade "B") in Metallurgy. Applicants should have a degree or equivalent qualification, with teaching experience, and be able to teach to Higher National Certificate standard. Industrial experience is also desirable. Salary scale: £700 by £27 10s. to £1,150 per annum, plus London allowance (£38 or £51). In assessing the commencing salary, increments above the scale minimum will be allowed for approved teaching, research, or industrial experience and national service. Additions to the salary scale will also be allowed for approved training and qualifications if in accordance with Burnham Further Education Report.

Application form and further particulars from the Clerk to the Governors.

SULLY HOSPITAL, SULLY, PENARTH, Glam. Senior Biochemist required. The hospital is Regional Thoracic Centre for treatment of all thoracic, including cardio-vascular conditions, in adults and children, and has full pathology, surgical and medical facilities, with cardio-respiratory laboratory and animal research laboratory. Work will include co-operation with surgical colleagues in research projects, and individual research will also be encouraged. N.H.S. conditions and salary (£1,250 to £1,700 per annum). Applicants should hold appropriate science degree of University of England, Wales, Scotland or Ireland or Associateship or Graduate Membership of the Royal Institute of Chemistry or such other qualification as may be approved for the purpose by the Minister of Health.—Form of application from Group Secretary, 44 Cathedral Road, Cardiff.

FORESTRY COMMISSION, ALICE HOLT Research Station, Farnham, Surrey: Scientific Officer (man or woman) for work on soils and nutrition of forest crops. Pensionable post for Physicist interested in biology or Biologist interested in physics and instrumentation. Age: at least 21 and normally under 29 on December 31, 1961. Qualifications: normally a degree, or Dip. Tech., with first- or second-class honours, or equivalent. Final year students may apply. Training in Soil Science not essential. Interim salary scale £717 to £1,186. Starting salary may be above minimum.—Application forms obtainable from Civil Service Commission, 17 North Audley Street, London, W.1, quoting **S/52/61/AH.** Applicants wishing to visit the Research Station, or obtain further particulars of its work, may write to the Chief Research Officer at Alice Holt Lodge.

AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

Division of Coal Research

The Organization's Division of Coal Research, Sydney, N.S.W., invites applications from qualified chemists for the following positions:

PHYSICAL OR INORGANIC CHEMIST

(No.: 480/349)

As part of a programme into the mechanisms and prevention of deposits on the fireside of boiler tubes, a Research Officer is required to initiate research into the behaviour of the inorganic constituents in coals and into the reactions of fused salts and inorganic oxides at high temperatures. Applicants should be honours graduates in Inorganic or Physical Chemistry (or equivalent) with some years' postgraduate research experience; experience in thermodynamics an advantage.

The appointment is offered for a period of three years.

SALARY: Dependent on qualifications and experience within the range £A.1,500 to £A.2,265 per annum.

CHEMIST

(No.: 480/350)

The appointee will assist investigations into the processes of combustion and gasification in beds of solid fuel on a pilot plant scale. He will be responsible for the instrumentation and operation of a high-intensity down-draft furnace in which the influence of fuel properties on aerodynamics, gas composition and temperature will be studied. The work involves correlation of experimental data with theoretical studies of the fuel bed processes.

Applicants should hold University Degree or Diploma in Science or Engineering (or equivalent qualifications) with experience in fuel technology or pilot plant and an interest in the application of mathematics to industrial problems.

CHEMIST

(No.: 480/351)

The appointee will carry out investigations into the relationship between the physical and chemical properties of molten slags. A Nernst Tamman furnace is available, and the appointee will be responsible for the development of suitable methods of slag viscometry. Representative coal slags are produced in a cyclone slagging combustion cyclone furnace and the appointee will form an integral part of a specialist group engaged on the elucidation of problems connected with the use of Australian coals for combustion and gasification in industrial furnaces.

Applicants should possess a University degree or Diploma in Science, or equivalent qualifications, with experience in the field of physical chemistry or physical metallurgy.

The appointments are for three years only; every endeavour will be made to find alternative employment at the end of this period.

Salary: Dependent on qualifications and experience within the ranges: £A.1,620 to £A.1,950 per annum or £A.2,070 to £A.2,330 per annum.

Salary for women will be £A.180 per annum less than corresponding rates for men.

Promotion within C.S.I.R.O. is by merit and may ultimately go beyond the upper limit of the scale within which the original appointment is made.

Fares paid, and if appointment is not extended return fares also paid. Further particulars of conditions, etc., supplied on application to:

Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2,

to whom applications (quoting relevant appointment number) should be addressed by May 6, 1961.

UNIVERSITY OF BELFAST

The Senate of the Queen's University of Belfast invites applications for an Assistant Lectureship in Physics from October 1, 1961. An interest in theoretical or experimental plasma physics is desirable. Salary scale £800 by £50 to £950 plus F.S.S.U. Initial placing on the scale will depend on qualifications and experience.

Applications should be received by April 29, 1961. Further particulars may be obtained from G. R. Cowie, M.A., LL.B., J.P., Secretary.

ASSISTANT TO THE CHIEF ENGINEER

Painton & Co. Ltd., manufacturers of high quality components for the Electronics Industry, are expanding their activities and wish to appoint an Assistant to the Chief Engineer. Applicants must be graduates in physics or electrical engineering, have experience in the design and development of electronic components and be able to carry executive authority. This is a staff appointment with superannuation scheme.

Applications to the Personnel Officer, Kingsthorpe, Northampton.

ROYAL VETERINARY COLLEGE. BIOlogy Technician required to work at the Royal Veterinary College assisting Research Fellow of the Zoological Society of London in Physiological and animal breeding work. Experience desirable. Salary scale: £490 to £675 per annum; plus London weighting. Starting point according to age and experience. Qualification allowance payable in certain circumstances.—Particulars in writing to Assistant Secretary, Royal Veterinary College, Royal College Street, London, N.W.1.

AN ORGANIC CHEMIST IS REQUIRED to assist in a project of research into the composition of cottonseed oil and the properties of its glycerides. The post offers good opportunities of fundamental research, and results of the investigation will be available for publication. The candidate should hold a university degree in chemistry.—Apply in writing to the Director of Research, The British Food Manufacturing Industries Research Association, Randalls Road, Leatherhead, Surrey, giving details of educational qualifications and experience, and state salary expected. The post carries comparable pension and life insurance rights. Applications should be marked "Private and Confidential."

WEST BROMWICH AND DISTRICT HOSPITALS MANAGEMENT COMMITTEE

(GROUP NO. 18)

MIDLAND CENTRE FOR NEUROSURGERY, SMETHWICK

Research Biochemist. Hospital devoted to treatment of diseases of the nervous system requires a medically qualified biochemist or graduate chemist with honours degree, and experience in protein or enzyme chemistry to conduct research in collaboration with the Pathologist into effects of diseases of muscle structure, and metabolism. There is a well equipped laboratory available and facilities including supervision for a higher degree will be available at the University of Birmingham, Department of Chemistry. Salary £1,250 to £1,700 per annum. The appointment is for two years in the first place. The laboratory may be visited by arrangement with the Pathologist, Dr. A. L. Woolf.

Applications, giving curriculum vitae and names of two referees, should be sent to the Group Secretary, West Bromwich and District H.M.C., Edward Street, West Bromwich.

UNIVERSITY COLLEGE OF NORTH WALES

BANGOR

Applications are invited for a Lectureship in the Department of Physics. The main research interests in the Department are Solid-state Physics and Molecular Physics. The salary scale is £1,050 by £50 to £1,400 by £75 to £1,850, and the initial salary will be according to qualifications and experience. In addition there are F.S.S.U. benefits and family allowances. The appointment will date from October 1, 1961.

Two copies of the application should reach the Registrar, University College of North Wales, Bangor, from whom further particulars may be obtained, not later than April 24, 1961.

LINCOLNSHIRE RIVER BOARD

APPOINTMENT OF TWO RIVER INSPECTORS

Applications are invited for the above-mentioned appointments. Preference will be given, in the case of one of the appointments, to persons in possession of the Associateship Certificate of the Institute of Sewage Purification and in the case of the other appointment to persons suitably qualified in biology. The salary will be in accordance with Grade APT II (£815 to £960) plus a 10 h.p. car travelling allowance.

Full details of the duties, etc., of these appointments can be obtained from the Board's Fisheries and Pollution Officer, 50 Wide Bargate, Boston, Lincs. Applications must be submitted to the under-mentioned to arrive not later than noon, April 17, 1961.

G. E. PHILLIPPO,
Clerk of the Board

50 Wide Bargate,
Boston, Lincs.

INSTITUTE OF OPHTHALMOLOGY

(UNIVERSITY OF LONDON)

JUDD STREET, W.C.1

A vacancy exists for a Senior Technician for work with Electron Microscope. Experience of normal histological techniques essential. Salary according to recognized scales.

Further particulars from and applications in writing, with names of two referees, to Secretary at above address.

SENIOR TECHNICIAN, GRADE I

Applications are invited from Fellows or Associates of I.M.L.T. qualified in histology for a vacancy occurring shortly in the Department of Morbid Anatomy. The post could be filled on a more junior basis according to qualifications and experience of applicants. The work will be concerned partly with experimental Pathology. Salary based on Whitley Council scale.

Applications to Dr. Martin Bodian, Department of Morbid Anatomy, The Hospital for Sick Children, Great Ormond Street, W.C.1.

TECHNICIAN FOR BIOCHEMICAL RESearch required by University Medical School. I.M.L.T. (Technician Grade) or equivalent qualifications or previous work in chemistry or physics required. Scope for some administrative work and work with an ultracentrifuge. Salary in accordance with Whitley Council scales.—Application forms, to be returned within seven days, from the Secretary, Institute of Psychiatry, the Maudsley Hospital, Denmark Hill, S.E.5. (Ref USAF/Bio).

FRUIT AND VEGETABLE CANNING AND QUICK FREEZING RESEARCH ASSOCIATION

There is an immediate vacancy for an Assistant Research Chemist to continue an investigation into the chemical constitution of fruits. Experience in chromatography would be an advantage. Although a degree in chemistry is essential, keen interest and experimental ability are preferred to high academic qualifications. The results of the work will be freely available for publication.

Applications, stating age, qualifications, experience, salary required, and the names of two referees, should be sent to the Director, Research Station, Chipping Campden, Glos.

MANSFIELD HOSPITAL MANAGEMENT COMMITTEE

Whole-time Biochemist (non-resident) required for hospital biochemical work in the Mansfield Area Pathology Service. The salary is that of the N.H.S. Basic Grade with a maximum of £1,035 per annum, the commencing salary being dependent upon qualifications and experience.

Applications to Hospital Secretary, King's Mill Hospital, Sutton-in-Ashfield, Notts.

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Applications are invited from graduates (male or female), or from those expecting to graduate in 1961, for a vacancy as Head of the Scientific Records Section at the Organization's headquarters in Edinburgh. Candidates should have studied mathematics or statistics as a principal subject in their university course. The appointment will be in either the Assistant Experimental Officer or the Experimental Officer grade, according to experience, the appropriate salary scales being as follows: Assistant Experimental Officer, £645 (age 22) to £983 per annum; Experimental Officer, £1,087 to £1,336 per annum.

Further particulars and application forms may be obtained from the Secretary of the Organization at 48 Palmerston Place, Edinburgh, 12. Closing date for applications is April 17, 1961.

UNIVERSITY COLLEGE

ADDIS ABABA
ETHIOPIA

Lecturers in Accounting, English Language and Literature, Geography, Pharmacy, Biochemistry, Inorganic Chemistry, Botany, Mathematics, Physics, Statistics, Zoology (Comparative Anatomy). Annual net salary £1,741 to £2,500 according to qualifications and teaching experience. Accommodation and passage.

Apply to President, University College, P.O.B. 399, Addis Ababa, Ethiopia.

ONTARIO VETERINARY COLLEGE

GUELPH, ONTARIO, CANADA

Applications are invited for an appointment as an Assistant or Associate Professor in Pharmacology. Applicants should have a Ph.D. and teaching experience. The candidate will lecture to undergraduate and postgraduate students in pharmacology and be expected to undertake research in some aspect of the field.

A curriculum vitae and references should be addressed to Dr. H. G. Downie, Professor and Head, Department of Physiological Sciences.

UNIVERSITY OF ALBERTA

DEPARTMENT OF CHEMISTRY
TEACHING ASSISTANTSHIPS

$2,200 to $2,700 for eight months are open to qualified students proceeding to advanced degrees. Nine hours per week of laboratory instruction required. Active research programmes in analytical, inorganic, organic, physical and theoretical chemistry. Travel allowance.

Apply to: Professor Harry E. Gunning, Head, Department of Chemistry, University of Alberta, Edmonton, Alberta, Canada.

UNIVERSITY OF HULL

Applications are invited for a Research Fellowship in the Chemistry Department, tenable for two years from September 1, 1961, for fundamental work on compounds of potential use in the paint industry. Salary £750 to £850 per annum; a Ph.D. degree or equivalent experience is required.

Applications (four copies) to the Professor of Chemistry, from whom further information may be obtained. Closing date, April 24.

UNIVERSITY OF DURHAM

CHAIR OF ZOOLOGY

Applications are invited for the Chair of Zoology tenable in the Durham Division of the University. Salary in accordance with the professorial scale (£2,600 to £3,000 a year), with family allowance and membership of F.S.S.U. The successful candidate will be required to take up duty on August 1, 1961, or such later date as may be arranged.

Further particulars may be obtained from the undersigned, with whom applications (12 copies) must be lodged not later than April 22, 1961. (Candidates outside the British Isles may submit one copy only.)

REGISTRAR.

University Office,
46 North Bailey, Durham.

MICROBIOLOGIST

(Female—Aged 25/30)

required with a degree in Microbiology or General Science in allied subjects.

The successful applicant will be engaged upon interesting work of a varying nature and in particular: Microbiological assay of antibiotics, collection of stock cultures and assessment of microbiological activity of new compounds. The post is situated in a small well-equipped modern laboratory and it will be necessary for the applicant to maintain and control this important section.

The future holds security and early opportunities for promotion, together with the usual benefits and excellent starting salary.

If you consider you can fill this position—apply in writing, giving career and personal details to date, to:

Personnel Manager,
Beecham Research Laboratories Ltd.,
Great West Road, Brentford, Middx.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

POSTDOCTORAL FELLOWSHIP IN FLAME SPECTROSCOPY

Applications are invited for a Postdoctoral Fellowship for research in Flame Spectroscopy or a related subject, sponsored by General Motors Corporation, Detroit, U.S.A., in the Department of Chemical Engineering, Imperial College, under the supervision of Dr. A. G. Gaydon, F.R.S. Value £900 per annum with family allowances and F.S.S.U.

Further particulars from Dr. A. G. Gaydon, Imperial College, London, S.W.7.

UNIVERSITY COLLEGE OF NORTH STAFFORDSHIRE

Applications are invited for the post of Demonstrator in Chemistry. The appointment is tenable from September 1, 1961. Remuneration £620 per annum.

Applications should reach the Registrar, The College, Keele, Staffs, from whom further particulars and application forms may be obtained, not later than April 14, 1961.

RESEARCH ASSISTANT REQUIRED FOR experimental research in human lung function and to assist in teaching. Candidates should possess an honours degree in physiology, physics or a biological subject. The holder of the post would be eligible to register as an internal Ph.D. student. Salary within the range £555 to £675. —Apply in writing to the Finance Officer, London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

PHARMACOLOGIST

Required to work in London for the first two years in an academic department and thereafter in a newly created Research Laboratory in London. Non-contributory Pension and Life Assurance Scheme and excellent salary: scope for promotion.

Write, giving full details of age, qualifications, experience and salary required, to the Managing Director, Biorex Laboratories Limited, 47-51 Exmouth Market, London, E.C.1.

UNIVERSITY OF MANCHESTER

Applications are invited for the post of Lecturer in Cytology in the Departments of Botany and Zoology in the Faculty of Science. Candidates should have a wide interest in the subject so as to be able to lecture to students of both departments. Duties to commence on October 1, 1961. Membership of F.S.S.U. and Children's Allowance Scheme. Salary on a scale £900 to £1,650 per annum, initial salary according to qualifications and experience.

Applications should be sent not later than April 25, 1961, to the Registrar, the University, Manchester, 13, from whom further particulars and forms of application may be obtained.

GLASSBLOWER

CHEMISTRY DEPARTMENT, QUEEN'S UNIVERSITY, KINGSTON, ONTARIO, CANADA

A Glassblower is required for the Chemistry Department. Salary according to qualifications.

Please write, including two recommendations, to Dr. J. K. N. Jones.

UNIVERSITY OF MANCHESTER

Applications are invited for the post of Assistant Lecturer in Inorganic Chemistry. Salary on a scale £800 to £950 per annum, with membership of the F.S.S.U. and children's allowance scheme.

Applications should be sent not later than April 15, 1961, to the Registrar, the University, Manchester 13, from whom further particulars and forms of application may be obtained.

LEICESTER ROYAL INFIRMARY

Applications are invited for the post of Technical Assistant (female) in the Physics Department. The duties are concerned with the medical applications of radioactive isotopes, and training will be given in the specialized techniques involved. Applicants should be 21 or over and should have reached the Advanced Level G.C.E. in physics and mathematics (or possess an equivalent qualification). Salary £570 with annual increments to maximum of £710.

Applications, stating age, qualifications, previous experience, etc., to the Secretary.

NATURE CONSERVANCY: ASSISTANT Experimental Officer. Pensionable post at St. Ives, Hunts., for man or woman for library and information work in Toxic Chemicals and Wildlife Section. Age: at least 18 and normally under 28 on December 31, 1961. Qualifications: preferably degree in chemistry and/or a biological subject. Alternatively, G.C.E. (or equivalent) with passes in English Language and four other subjects, two of which must be scientific subjects at "A" level. Experience of library work and knowledge of German desirable. Starting salary £450 (at 18) to £776 (at 26 or over), rising to £957.—Write Civil Service Commission, 17 North Audley Street, London, W.1, for an application form, quoting **S/94-95/61/TCWS**. Early application advised.

RESEARCH ASSISTANT WANTED AT Stoke Mandeville Hospital to help with current research on an immunological project connected with Rheumatoid Arthritis. The person appointed would work directly with the Pathologist undertaking the research. Salary £750 to £1,000 per annum according to qualifications.—Inquiries and applications, giving details of experience and the names of two referees, to the Pathologist, Stoke Mandeville Hospital, Aylesbury, Bucks.

STATISTICIAN REQUIRED FOR AGRICULtural Research Council's Unit of Statistics (University of Aberdeen). Applicants should have a good honours degree in mathematics or science and knowledge of statistical techniques as applied to agriculture or biology. Appointment in Scientific Officer (£738 to £1,222) or Senior Scientific Officer (£1,342 to £1,654) grade according to age and experience. Superannuation under F.S.S.U.—Applications, with names of three referees to the Secretary, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1, not later than April 22, 1961.

GRADUATE CHEMIST OR PHYSICAL Chemist (age 23 to 30 years) is required for work on techniques employed in the fractionation of proteins in human plasma. This work includes the development of laboratory procedures for use on a small production scale. This post provides a unique opportunity of gaining experience in physico-chemical methods of separating proteins. —Apply in writing, stating age, qualifications and experience, and with names of two referees, to: Secretary, Lister Institute of Preventive Medicine, Elstree, Herts.

AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

Division of Coal Research

The Organization's Division of Coal Research, Sydney, N.S.W., invites applications from qualified chemists for the following positions:

PHYSICAL OR INORGANIC CHEMIST

(No.: 480/349)

As part of a programme into the mechanisms and prevention of deposits on the fireside of boiler tubes, a Research Officer is required to initiate research into the behaviour of the inorganic constituents in coals and into the reactions of fused salts and inorganic oxides at high temperatures. Applicants should be honours graduates in Inorganic or Physical Chemistry (or equivalent) with some years' postgraduate research experience; experience in thermodynamics an advantage.

The appointment is offered for a period of three years.

SALARY: Dependent on qualifications and experience within the range £A.1,580 to £A.2,265 per annum.

CHEMIST

(No.: 480/350)

The appointee will assist investigations into the processes of combustion and gasification in beds of solid fuel on a pilot plant scale. He will be responsible for the instrumentation and operation of a high-intensity down-draft furnace in which the influence of fuel properties on aerodynamics, gas composition and temperature will be studied. The work involves correlation of experimental data with theoretical studies of the fuel bed processes.

Applicants should hold University Degree or Diploma in Science or Engineering (or equivalent qualifications) with experience in fuel technology or pilot plant and an interest in the application of mathematics to industrial problems.

CHEMIST

(No.: 480/351)

The appointee will carry out investigations into the relationship between the physical and chemical properties of molten slags. A Nernst Tamman furnace is available, and the appointee will be responsible for the development of suitable methods of slag viscometry. Representative coal slags are produced in a cyclone slagging combustion cyclone furnace and the appointee will form an integral part of a specialist group engaged on the elucidation of problems connected with the use of Australian coals for combustion and gasification in industrial furnaces.

Applicants should possess a University degree or Diploma in Science, or equivalent qualifications, with experience in the field of physical chemistry or physical metallurgy.

The appointments are for three years only; every endeavour will be made to find alternative employment at the end of this period.

Salary: Dependent on qualifications and experience within the ranges: £A.1,620 to £A.1,950 per annum or £A.2,070 to £A.2,330 per annum.

Salary for women will be £A.180 per annum less than corresponding rates for men.

Promotion within C.S.I.R.O. is by merit and may ultimately go beyond the upper limit of the scale within which the original appointment is made.

Fares paid, and if appointment is not extended return fares also paid. Further particulars of conditions, etc., supplied on application to:

Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2,

to whom applications (quoting relevant appointment number) should be addressed by May 6, 1961.

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Clerk of the Board

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(UNIVERSITY OF LONDON)

JUDD STREET, W.C.1

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ETHIOPIA

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A curriculum vitae and references should be addressed to Dr. H. G. Downie, Professor and Head, Department of Physiological Sciences.

UNIVERSITY OF ALBERTA
DEPARTMENT OF CHEMISTRY
TEACHING ASSISTANTSHIPS

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Apply to: Professor Harry E. Gunning, Head, Department of Chemistry, University of Alberta, Edmonton, Alberta, Canada.

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CHAIR OF ZOOLOGY

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(Female—Aged 25/30)

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Personnel Manager,
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IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY
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UNIVERSITY OF MANCHESTER

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GLASSBLOWER
CHEMISTRY DEPARTMENT, QUEEN'S UNIVERSITY, KINGSTON, ONTARIO, CANADA

A Glassblower is required for the Chemistry Department. Salary according to qualifications.

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Applications are invited for the post of Technical Assistant (female) in the Physics Department. The duties are concerned with the medical applications of radioactive isotopes, and training will be given in the specialized techniques involved. Applicants should be 21 or over and should have reached the Advanced Level G.C.E. in physics and mathematics (or possess an equivalent qualification). Salary £570 with annual increments to maximum of £710.

Applications, stating age, qualifications, previous experience, etc., to the Secretary.

NATURE CONSERVANCY: ASSISTANT Experimental Officer. Pensionable post at St. Ives, Hunts., for man or woman for library and information work in Toxic Chemicals and Wildlife Section. Age: at least 18 and normally under 28 on December 31, 1961. Qualifications: preferably degree in chemistry and/or a biological subject. Alternatively, G.C.E. (or equivalent) with passes in English Language and four other subjects, two of which must be scientific subjects at "A" level. Experience of library work and knowledge of German desirable. Starting salary £450 (at 18) to £776 (at 26 or over), rising to £957.—Write Civil Service Commission, 17 North Audley Street, London, W.1, for an application form, quoting **S/94-95/61/TCWS**. Early application advised.

RESEARCH ASSISTANT WANTED AT Stoke Mandeville Hospital to help with current research on an immunological project connected with Rheumatoid Arthritis. The person appointed would work directly with the Pathologist undertaking the research. Salary £750 to £1,000 per annum according to qualifications.—Inquiries and applications, giving details of experience and the names of two referees, to the Pathologist, Stoke Mandeville Hospital, Aylesbury, Bucks.

STATISTICIAN REQUIRED FOR AGRICULtural Research Council's Unit of Statistics (University of Aberdeen). Applicants should have a good honours degree in mathematics or science and knowledge of statistical techniques as applied to agriculture or biology. Appointment in Scientific Officer (£738 to £1,222) or Senior Scientific Officer (£1,342 to £1,654) grade according to age and experience. Superannuation under F.S.S.U.—Applications, with names of three referees to the Secretary, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1, not later than April 22, 1961.

GRADUATE CHEMIST OR PHYSICAL Chemist (age 23 to 30 years) is required for work on techniques employed in the fractionation of proteins in human plasma. This work includes the development of laboratory procedures for use on a small production scale. This post provides a unique opportunity of gaining experience in physico-chemical methods of separating proteins. —Apply in writing, stating age, qualifications and experience, and with names of two referees, to: Secretary, Lister Institute of Preventive Medicine, Elstree, Herts.

NATIONAL INSTITUTE OF AGRICULTURAL BOTANY

ASSISTANT DIRECTOR

Applications are invited for the post of Assistant Director of the Institute. Salary scale £1,840, by annual increments to a maximum of £2,540; in addition a responsibility allowance of £275 per annum will be paid. Superannuation under the F.S.S.U. Scheme. Applicants must hold a recognized degree or equivalent qualification and have a wide experience in agricultural botany or in crop husbandry. Experience of administration and of supervising the production of technical reports is highly desirable. Applications should be received by May 1, 1961.

Further particulars may be obtained from F. R. Horne, C.B.E., M.A., Director, N.I.A.B., Huntingdon Road, Cambridge.

EXAMINERS

MINISTRY OF EDUCATION FOR NORTHERN IRELAND

GRAMMAR SCHOOL JUNIOR AND SENIOR CERTIFICATE EXAMINATIONS

Applications are invited from persons with appropriate qualifications and experience for appointment to the panels of examiners in the following subjects in particular:

Geography, Algebra, Arithmetic, Geometry, Trigonometry, Domestic Science, Experimental Science, Biology (Senior), Modern History (Senior), History (Junior) and English Literature (Senior).

Application forms and further information may be obtained from the Ministry at Netherleigh, Massey Avenue, Belfast, 4. Persons who have already applied need not re-apply unless circumstances have changed.

ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY

GLASGOW

DEPARTMENT OF MATHEMATICS

Applications are invited for a Research Fellowship in Mathematics. The salary scale is £800 by £50 to £950, and the initial salary will depend upon qualifications. All appointments carry with them family allowances and membership of F.S.S.U.

Applications should be lodged with the Secretary of the College (from whom further details may be obtained), not later than April 22, 1961, and should include the names of two referees.

W. G. PYE & CO. LTD.

Chemist required, for electrochemical development work in an interesting field. Graduate or A.R.I.C. level. Excellent salary and conditions.

Please apply: Personnel Officer, W. G. Pye & Co., Ltd., P.O. Box No. 60, Cambridge.

INSTITUTE OF CANCER RESEARCH: Royal Cancer Hospital. Technician required in Physics Department, Sutton, Surrey, to assist in chemical section of laboratory engaged in radiobiological research. Varied work involving a wide range of chemical and physical techniques. Applicants should possess National Certificate, City and Guilds Certificate or similar qualification. Salary on M.R.C. scales according to qualifications and experience within range £595 to £860.—Applications with names of two referees (one of whom should be acquainted with candidate's recent work) to the Secretary, 33 Sumner Place, S.W.7, quoting ref. 301/B/59.

EXPERIMENTAL OFFICER, FOR WORK on biochemical problems associated with the diseases of farm animals and the fundamental study of protein and nucleic acid biosynthesis. Salary on scale £1,057 to £1,336 per annum. Superannuation. Hostel accommodation available if required.—Applications, with the names of three referees, to Secretary, Agricultural Research Council, Field Station, Compton, near Newbury, Berks.

MINERALOGIST, PREFERABLY WITH Ph.D. degree, salary and appointment according to training and experience. Vacancy to be filled prior to September 1, 1961.—Department of Geology, University of New Brunswick, Fredericton, New Brunswick, Canada.

RESEARCH ASSISTANT (SENIOR TECHNICIAN grade) wanted for interesting research in amino acid metabolism in health and disease. Laboratory experience in chemistry or biochemistry (industrial or hospital) necessary. Starting salary in range £645 to £870 per annum, according to experience (scale being revised).—Apply by letter to Dr. Woolf, Department of the Regius Professor of Medicine, Radcliffe Infirmary, Oxford.

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LECTURER IN CHEMISTRY

Applications are invited for the above post. Candidates should have research experience. The appointee will be expected to teach undergraduates and carry on fundamental research. The appointment is probationary for the first two years.

Applications should include names of two referees to whom application may be made for references. Details of papers published and research interests should also be given. Further particulars can be obtained from Professor J. K. N. Jones.

LEVY WEST LABORATORIES OF Wembley require a graduate for work on very pure inorganic chemicals. Some physical leanings useful. Outside experience helpful but not essential. Salary according to qualifications.—Write or telephone Wembley 1088.

APPLICATIONS ARE INVITED FROM graduates and prospective graduates in science to undertake physicochemical research on biological macromolecules.—Applications, with details of academic career, should be sent to Dr. P. Johnson, Department of Colloid Science, Free School Lane, Cambridge.

APPLICATIONS INVITED FOR POST OF Senior Technician (male) in the Biology Department of Repton School, Repton, Derby. Salary £450 to £720, position on scale dependent upon experience.—Write with testimonial and name of referee to Mr. W. A. C. Bullock, Senior Biologist, Repton School, giving full details of qualifications and experience.

PHYSIOLOGIST, LECTURER, DEPARTment of Physiology, University of Ottawa, Ottawa, Canada. Applicants should have an M.D. or a Ph.D. degree. Salary up to $6,000, depending on experience. Pension plan, hospital insurance.—Applications and inquiries should be forwarded to Professor M. Beznak at the above address.

MEDICAL RESEARCH COUNCIL OF IRELAND

Applications are invited from B.Sc. graduates or Associates of Institute of Medical Laboratory Technology, for a position in a clinical metabolic unit (St. Vincent's Hospital, Dublin). Applicants should preferably, but not necessarily, have previous experience of this type of work, and some knowledge of radioisotope techniques. Salary offered depends on qualifications and experience.

Applications, giving full details and names of two referees, should reach the Secretary, Medical Research Council of Ireland, 50 Merrion Square, Dublin 2, on or before April 17, 1961.

UNIVERSITY OF GLASGOW

UNIVERSITY STUDENTSHIPS AND FELLOWSHIPS

Applications are invited for University Studentships and Fellowships for experimental or theoretical research in Solid State Physics. Salary scale: Studentships, £350 to £600 per annum, according to qualifications, with a tenure of three years. Fellowships, £700 to £1,000 per annum, according to qualifications. Tenure three years on appointment, with possible renewal for further period of two years. These Fellowships will be superannuated under the F.S.S.U.

Applications, stating age, academic qualifications, research experience and names of two referees, should be sent to the Professor of Natural Philosophy, University of Glasgow, before May 13, 1961.

CITY AND COUNTY OF BRISTOL EDUCATION COMMITTEE

BRISTOL TECHNICAL COLLEGE

DEPARTMENT OF SCIENCE

The Governors invite applications for post of Lecturer in Biology, to commence September 1, 1961. Applicants should possess good academic qualifications and be able to teach mainly Zoology to Ordinary National Certificate level, and later to Higher National Certificate level. Subsidiary Physiology would be an additional qualification. Burnham Technical Scale salary, £1,370 to £1,550. Commencing salary dependent upon qualifications and experience.

Details and application forms, returnable as soon as possible, from Registrar, Bristol Technical College, Ashley Down, Bristol, 7. Please quote reference number BTC61/10.

UNIVERSITY OF CAMBRIDGE

CAVENDISH LABORATORY

ASSISTANT DIRECTOR OF RESEARCH IN ELECTRON MICROSCOPY

Applications are invited for the position of Assistant Director of Research in the Electron Microscope Section of the Cavendish Laboratory. Candidates should have had post-doctoral research experience, preferably in the application of the electron microscope and related physical methods in Biology or Medicine. The appointment will be for five years in the first instance. Salary range £1,250 to £1,850, with F.S.S.U. participation and Family Allowance.

Further particulars may be obtained from the Secretary of the Appointments Committee of the Faculty of Physics and Chemistry, Chemical Laboratory, Lensfield Road, Cambridge, to whom applications should be sent not later than May 1, 1961.

STUDENT LABORATORY TECHNICIAN required. Facilities for training and study for the examinations of the I.M.L.T. Salary in accordance with Whitley scales.—Forms of application may be obtained from Secretary, Forest Group H.M.C., Langthorne Road, E.11.

MARIE CURIE MEMORIAL FOUNDATION

Senior Research Scientist, preferably with medical qualification, to take charge of new laboratory unit and undertake research into the Biochemical aspects of Cancer. Candidates should be of high academic standing in biochemistry.

Salary scales for a scientist with a medical qualification will be £2,000 to £3,000 per annum, and without a medical qualification £1,800 to £2,500 per annum. Contributory Superannuation Scheme.

Applications should be made before April 15, 1961, to the Secretary, 124 Sloane Street, London, S.W.1, from whom further information may be obtained.

CITY OF LEICESTER EDUCATION COMMITTEE

LEICESTER COLLEGE OF TECHNOLOGY AND COMMERCE

Principal: R. E. Wood, M.Sc., F.Inst.P.

Applications are invited for the position of full-time Research Assistant in the Department of Biology. Applicants should possess a good honours degree in physiology, pharmacy (with pharmacology) or pharmacology and will be expected to work on pharmacological topics in accordance with the research programme of the Department. Appointment in the first instance for three years. Salary equivalent to minimum of Burnham Scale for Assistants Grade A, with additions for graduate qualifications and training. The minimum of Grade A is £520 plus £165 for a good honours degree, together with allowances for training.

Applications should be sent to the Registrar at the College as soon as possible.

JUNIOR TECHNICAL OFFICERS REQUIRED

Junior Technical Officers are required immediately by the Radiobiological Research Unit of the Medical Research Council. Minimum qualification two passes in science subject in G.C.E. at "A" level. Salary scale £410 at 18 rising to £860, with good prospects of promotion to Technical Officer (salary scale £920 to £1,260).

Applications, giving full particulars and the names of two referees, should be sent to Administrator, Radiobiological Research Unit, Medical Research Council, Harwell, Berks.

UNIVERSITY OF LIVERPOOL

Applications are invited for the post of Assistant Lecturer or Lecturer for work at the University Tidal Institute and Observatory. Preference will be given to candidates with an honours degree in mathematics. The initial salary will be within the range £800 to £1,250 per annum, according to age, qualifications and experience.

Applications, stating age, academic qualifications and experience, together with the names of three referees, should be received not later than April 4, 1961, by the Registrar, from whom further particulars of the conditions of appointment may be obtained. Quoting reference CV/N.

CITY OF PLYMOUTH EDUCATION COMMITTEE

PLYMOUTH AND DEVONPORT TECHNICAL COLLEGE

Principal: Eric Bailey, B.Sc., F.R.I.C., A.M.I.Chem.E.

Required April 1, or as soon as possible thereafter, Assistant Grade A in the Chemistry Department. Duties include maintenance and operation of Phillips E.M. 100 electron microscope, instruction in its use, supervision of other electronic equipment and certain teaching duties. Salary: Burnham Technical Report Grade A Assistant, £520 by £27 10s. to £1,000. Initial salary according to qualifications and previous experience.

Forms and particulars (s.a.e.) obtainable from Clerk to the Governors, to whom they should be returned as soon as possible.

SIR JOHN CASS COLLEGE

JEWRY STREET, LONDON, E.C.3

DEPARTMENT OF MATHEMATICS

The Governors invite applications for an additional appointment as Lecturer in Mathematics. Applicants should have a good honours degree and preferably a higher degree. The appointment, depending on qualifications and experience, will be made within the grade of Lecturer, salary range £1,370 by £35 by £40 to £1,550 plus London allowance of £38 or £51, or Assistant Lecturer, Grade B, salary range £700 by £27 10s. by £37 10s. to £1,150 with additions to the minimum for training and experience, plus London allowance of £38 or £51.

Details and forms of application may be obtained from the Secretary.

UNIVERSITY OF SOUTHAMPTON—Computation Laboratory. A second Maintenance Engineer is required for a Ferranti Pegasus installation. Applicants should hold H.N.C. or equivalent, and be familiar with electronic techniques. Experience of digital systems and/or teleprinter equipment will be an advantage, but training will be given where necessary. Salary in the range £750 by £25 to £1,000.—Applications (in duplicate), giving details of age, experience and the names of two referees, should be sent to the Secretary and Registrar, The University, Southampton, as soon as possible.

BATTERSEA COLLEGE OF TECHNOLOGY

LONDON, S.W.11

Applications are invited for an Assistant Lectureship in Physical Chemistry. Preferably with Ph.D. or equivalent postgraduate research experience. A knowledge of electronics or radiochemistry desirable. Salary within the range £950 to £1,486 less statutory deductions.

Further particulars from the Clerk to the Governing Body, by whom applications should be received as soon as possible.

ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY

GLASGOW

Applications are invited for a Senior Lectureship in Mathematics. Candidates should be prepared to initiate research in some branch of Pure or Applied Mathematics. The salary scale is £1,975 by £75 to £2,275. Superannuation is through the F.S.S.U. and children's allowances are paid.

Applications, together with the names of not more than three referees, should be lodged with the Secretary of the College (from whom further details may be obtained), not later than April 22, 1961.

LECTURES AND COURSES

ROTHERHAM COLLEGE OF TECHNOLOGY

DEPARTMENT OF PHYSICS

A short Full-time Course in HIGH VACUUM TECHNOLOGY will be held during the period Monday, June 26 to Friday, June 30, 1961 from 9.30 a.m. to 5 p.m. daily

The course is designed to cover the fundamentals of the production and measurement of high vacua. It should be of particular interest to those requiring high vacuum as an ancillary to their main interest.

Full details of the course may be obtained from the Registrar, College of Technology, Howard Street, Rotherham.

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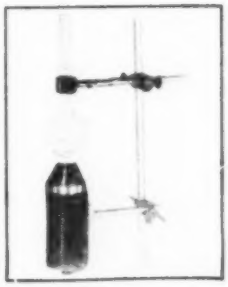

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CITY OF LIVERPOOL EDUCATION COMMITTEE

COLLEGE OF TECHNOLOGY
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POSTGRADUATE COURSES—SUMMER, 1961

1. Two-weeks' full-time courses. (a) "Radiobiology" May 1 to 12. (b) "Radiochemistry" (R.C.1) June 19 to 30. (c) "Radiation Safety and Health Physics" (R.S.16) September 18 to 29.

2. Short full-time courses. (a) "Practical Chromatography" July 5 to 7. (In collaboration with the Extra-mural Department of the University of Liverpool). (b) "Microscopy for Science Graduates" July 6 to 8. (c) "Course for Teachers of Chemistry" July 7 and 8.

Further details and application forms can be obtained from the Head of the Department of Chemistry and Biology.

THOMAS ALKER,
Town Clerk and Clerk to the
Local Education Authority. (J.6725)

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

SOUTH KENSINGTON, LONDON, S.W.7

CHEMICAL ENGINEERING

Applications are invited for the postgraduate courses in chemical engineering in the Department of Chemical Engineering and Chemical Technology.

Information is available from the Registrar, or by writing direct to the Professor of Chemical Engineering Science, Professor K. G. Denbigh.

WOLVERHAMPTON AND STAFFORDSHIRE COLLEGE OF TECHNOLOGY

Principal: Robert Scott, M.A., B.Sc., Dip.Ed.

DEPARTMENT OF APPLIED SCIENCE

Head of Department: A. G. Catchpole, B.Sc., Ph.D., F.R.I.C.

Two-day Symposium, May 11 and 12, 1961. Six lectures will be given at the College dealing with: "Recent Advances in the Biochemistry of Fats." Enrolment Fee: £2 2s. Organizer: B. M. Wilson, Ph.D.

Lecturers will include Professor Fraser (Birmingham), Dr. G. Hübscher (Birmingham), Dr. A. Jones (N.I.M.R.), Dr. D. Robinson (Oxford), and Dr. J. Lovern (Torry Research Station).

Details and application forms from the Principal, Wolverhampton and Staffordshire College of Technology, Wulfruna Street, Wolverhampton.

FOR SALE AND WANTED

OERTLING MICROGRAM BALANCE, TYPE 61PA/PB, model No. 38385, new November, 1950, serviced regularly by Oertling.—Can be seen at, or offers to, Nuffield Laboratory of Ophthalmology, Walton Street, Oxford (Oxford 48996).

GRANTS & SCHOLARSHIPS

BRITISH SOCIETY OF ANIMAL PRODUCTION

TRAVELLING SCHOLARSHIP

From funds provided by the Pig Industry Development Authority the above Society can offer a postgraduate travelling scholarship of £500 for a period of six months for study, on the continent of Europe, on any aspect of pig research including economics and marketing. Applicants should have completed one to two years' research training, not necessarily with pigs. The successful candidate will be attached to a prominent research centre for most of the time but will be expected to visit other centres within reasonable distance.

Application forms, obtainable from the Secretary of the British Society of Animal Production, West of Scotland Agricultural College, Auchincruive, Ayr, must be returned by April 22, 1961.

UNIVERSITY OF CAMBRIDGE

HUNTING GROUP SCHOLARSHIP IN THE APPLICATIONS OF AERIAL PHOTOGRAPHY

The Hunting Group of Companies have established a postgraduate scholarship for research into the applications of aerial photography to a specific field of knowledge; for the first award preference will be given to candidates who choose as their field the discovery and development of natural resources. Candidates must be citizens of the United Kingdom or of the Commonwealth. The scholarship will be tenable for a period of three years from October 1, 1961; its value will be £500 a year plus approved fees. In addition substantial financial assistance will be available towards the cost of travelling in connection with the scholar's research. The successful candidate will be required to become registered as a Research Student in the University of Cambridge.

Further particulars can be obtained from the Curator in Aerial Photography, Sidgwick Avenue, Cambridge, to whom applications, accompanied by a brief statement of the candidate's educational qualifications and of his proposed research, together with the names of two referees, should be sent so as to reach him not later than May 15, 1961.

SUNDERLAND EDUCATION AUTHORITY

THE TECHNICAL COLLEGE
RESEARCH STUDENTSHIPS

Applications are invited for Research Studentships in Applied Electronics and Automatic Control, Chemistry, Civil Engineering, Metallurgy, Pharmacy, Pharmacology and Physics. Candidates should hold a good honours degree or equivalent qualification. Undergraduates in their final year will be considered. Appointments tenable from September 1, 1961 are normally for a period of two to three years, subject to annual review. Successful candidates will be expected to work for higher degrees or Membership of the College of Technologists. The annual value of each studentship is £500.

Further particulars and forms of application may be obtained from the Registrar, Technical College, Sunderland, Co. Durham. Completed applications should be forwarded to the undersigned.

W. THOMPSON,
Director of Education.

Education Offices,
15 John Street,
Sunderland, Co. Durham.

MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY

(Faculty of Technology in the University of Manchester)

UNDERGRADUATE AND RESEARCH SCHOLARSHIPS

Applications are invited for the Bowater and the Wiggins Teape Group Research Scholarships, valued at £500 per annum each, and the Porritts and Spencer Ltd. undergraduate Scholarship, valued at £350 per annum. The research scholars will be expected to prepare for the degree of M.Sc.Tech. or Ph.D., and the undergraduate scholar for the degree of B.Sc.Tech., in the Paper Science Section of the Department of Textile Chemistry.

Application forms, copies of the regulations, and details of present research interests may be obtained from the Registrar, the Manchester College of Science and Technology, Manchester 1, to whom applications should be submitted by April 30, 1961.

UNIVERSITY OF LEICESTER

Applications are invited for a number of Research Scholarships in Arts, Science and the Social Sciences, tenable at the University for one or two years and of an annual value of £330 plus fees.

Particulars and application forms may be obtained from the Registrar. Closing date for applications May 7.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

A Research Studentship, of value £450 per annum plus fees and leading to Ph.D., is available for fundamental research in the field of Surface Chemistry.

Applications from prospective graduates in chemistry (or related sciences) should be sent before June 1, to Dr. J. A. Kitchener, Mineral Technology Research Laboratories, Imperial College, London, S.W.7, from whom further particulars may be obtained.

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COMMITTEE ON HIGHER EDUCATION

INVITATION TO GIVE EVIDENCE

The Committee on Higher Education appointed by the Prime Minister under the chairmanship of Lord Robbins is ready to receive written evidence and would like to do so within the next three months. The Committee's terms of reference are:

"To review the pattern of full-time higher education in Great Britain and in the light of national needs and resources to advise Her Majesty's Government on what principles its long-term development should be based. In particular, to advise, in the light of these principles, whether there should be any change in that pattern, whether any new types of institution are desirable and whether any modification should be made in the present arrangements for planning and co-ordinating the development of the various types of institution."

It will help the Committee to plan their business if any person or organisation wishing to make such representations to them informs me quickly of their intention to do so.

P. S. ROSS,
Secretary.

Committee on Higher Education,
Old County Hall,
Spring Gardens, S.W.1.

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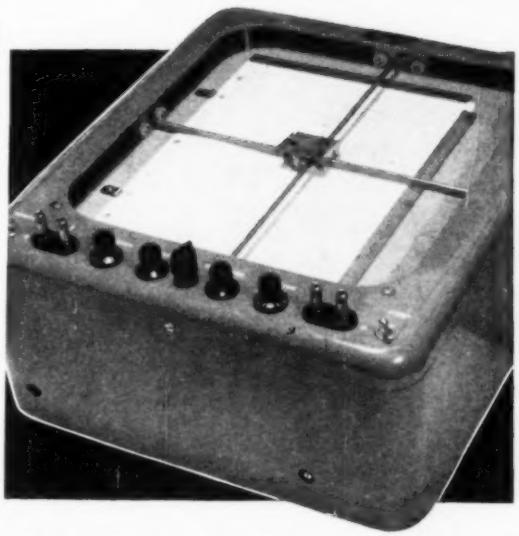

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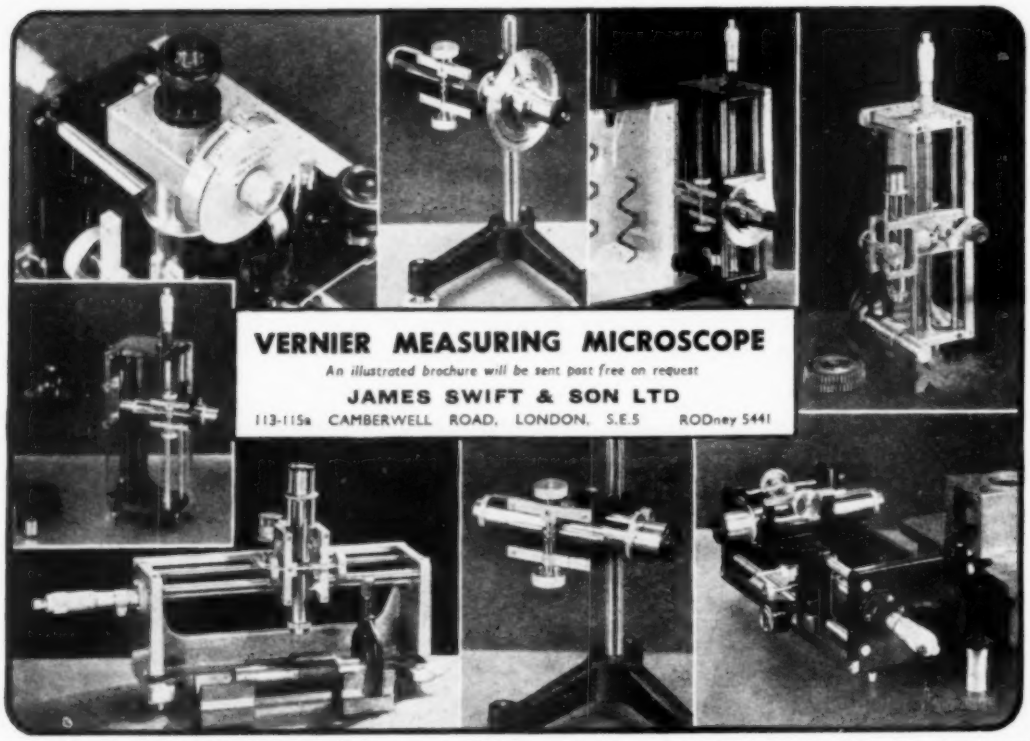

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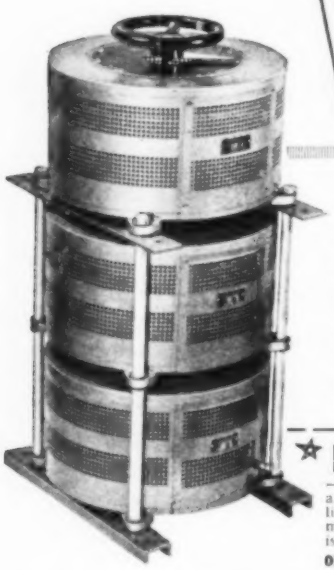

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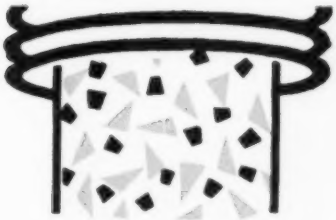

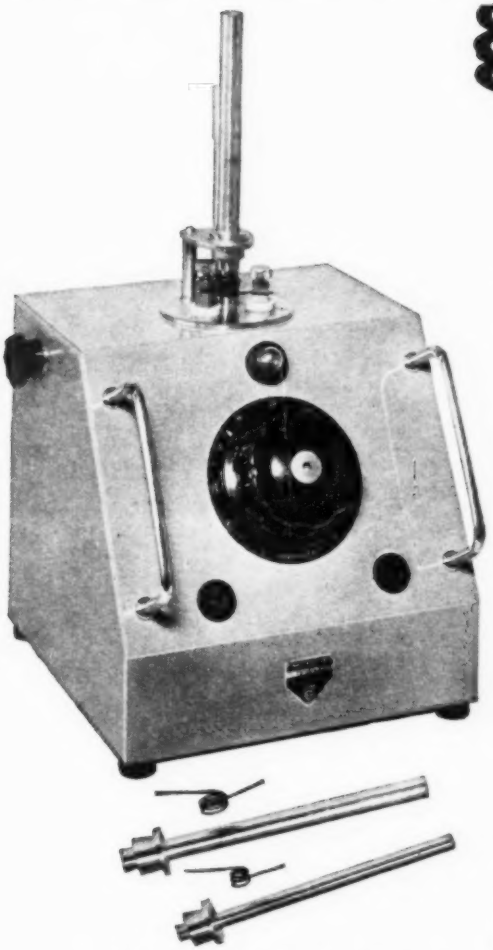

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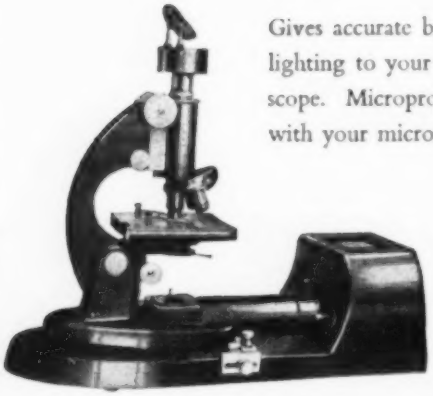

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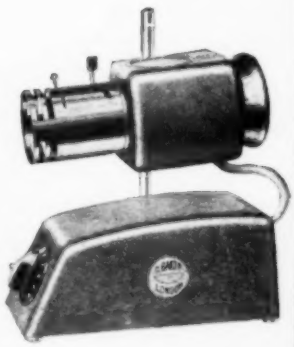

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